

Photochemically Deposited Contaminant Film Effects: Data Archive

Volume 2—Appendices A through D

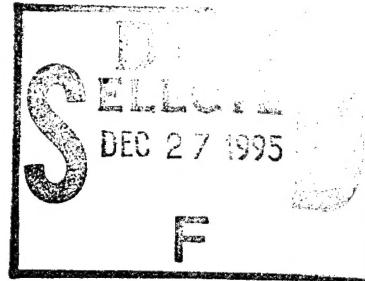
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Appendix A—Bisphenol

SPECTRA AND FIT RESULTS FOR THE BISPHENOL-A PHOTODEPOSIT

This appendix archives the deposition data and transmission spectra measured during a roughly 17 day continuous experiment in which a contaminant film was photochemically deposited from the precursor material bisphenol-a. This model contaminant serves as an analog for the materials that outgas from epoxy adhesives and composites.

1.0 DEPOSITION DATA AND TRANSMISSION SPECTRA

Figure A1 shows the TQCM data measured during the photochemical deposition of bisphenol. The film grew at a rate of about 1 Hz/hour (0.04 nm/hour) throughout most of the 500 hour experiment.

The nominal film thickness was calculated assuming a density equal to that of the starting material and a TQCM calibration coefficient of 4.43 ng/cm²/Hz. Table A1 shows the nominal thicknesses at which visible (695-355 nm) transmission spectra were measured. Table A2 shows the nominal thicknesses at which ultraviolet (395-225 nm) transmission spectra were measured.

Table A1 Nominal film thicknesses, nm, at which visible wavelength range spectra were measured.

0.0	0.99	2.6	3.3	3.3	3.3	6.5	7.9	15.8	17.6	19.2
19.9	21.4	22.8	25.5	26.8	26.8					

Table A2 Nominal film thicknesses, nm, at which ultraviolet wavelength range spectra were measured.

0.0	0.99	2.6	3.2	3.2	6.5	7.9	15.8	17.5	19.2
19.9	21.3	22.8	25.5	26.8					

The transmission spectra are plotted in Figures A2 through A8. Where multiple measurements were made at a single thickness, the data are overplotted.

2.0 BEER'S LAW FITS

The transmission spectra were fit to the Beer-Lambert absorption law,

$$\log_e(I/I_0) = -\alpha t \quad (\text{A1})$$

where I/I_0 is the transmittance of the film, t is the film thickness, and α is the absorption coefficient of the film. The transmittance of the film was calculated as the ratio of the transmission of the deposit, on the substrate, to the transmission of the clean substrate. Note that the quantity $\log(I/I_0)$ will be called the film absorbance.

Figures A9 and A10 present the results of this analysis. The linear least-squares fits were not constrained to pass through the origin. Figure A11 shows the ratio of the fitted intercept to the absolute value of the largest absorbance measured. The relatively small values in this plot indicate reasonably good fits. The actual fits are shown in Figure A12 for the visible wavelengths, and A13 for the ultraviolet wavelengths.* Tables A3 and A4 present the results of the visible and ultraviolet fits, respectively.

Although there is a fair amount of scatter in the plots shown in Figures A12 and A13, the fits are remarkably satisfying.

3.0 Constrained Fits

Because data for some of the materials studied show curvature of the absorbance vs. thickness plots, a second approach was used to extract an apparent absorption coefficient from the data. In this case, the "Beer's law plot" is constrained to pass through the origin, by calculating an apparent α as

$$\alpha = \langle \alpha_j \rangle = \frac{1}{j_f - j_i + 1} \sum_{j=j_i}^{j=j_f} \frac{\log_e[I(t_j)/I_0]}{t_j} \quad (\text{A2})$$

where I/I_0 is the transmittance of the film, t_j is the film

* Note that the plots show the absorption coefficient as a negative number, which is opposite to the sign convention shown in equation A1.

thickness for the j th measurement, and α is the absorption coefficient of the film. The transmittance of the film was calculated as the ratio of the transmission of the deposit, on the substrate, to the transmission of the clean substrate.

Figures A14 and A15 present the results of this analysis, where the average was performed for all film thicknesses. The constrained data, α_j , are shown in Figure A16 for the visible wavelengths, and A17 for the ultraviolet wavelengths. Tables A5 and A6 present the results of the visible and ultraviolet fits, respectively.

4.0 COMPARISON OF THE FITS

Figures A18 and A19 provide comparisons of the apparent absorption coefficients obtained from the two fitting approaches. They are everywhere in agreement to within better than a factor of two.

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Table A3. Beer's law fit results for the bisphenol photodeposit, visible wavelength range.

Wavelength (nm)	Apparent α (μm^{-1})	Intercept
695	0.18	0.000
690	0.23	0.001
685	0.24	0.001
680	0.25	-0.001
675	0.25	-0.001
670	0.23	0.000
665	0.26	0.000
660	0.28	0.000
655	0.27	-0.001
650	0.28	0.000
645	0.30	-0.001
640	0.29	0.000
635	0.29	-0.001
630	0.31	0.000
625	0.32	0.000
620	0.34	0.000
615	0.34	0.000
610	0.36	0.000
605	0.37	0.000
600	0.37	0.000
595	0.39	0.000
590	0.39	0.000
585	0.40	0.000
580	0.42	0.000
575	0.43	0.000
570	0.45	0.000
565	0.46	0.001

Table A3, continued.

Wavelength (nm)	Apparent α (μm^{-1})	Intercept
560	0.46	0.000
555	0.48	0.000
550	0.51	0.001
545	0.52	0.001
540	0.53	0.000
535	0.56	0.000
530	0.58	0.001
525	0.60	0.001
520	0.62	0.001
515	0.64	0.000
510	0.67	0.001
505	0.70	0.001
500	0.72	0.001
495	0.74	0.001
490	0.78	0.001
485	0.81	0.001
480	0.85	0.001
475	0.88	0.001
470	0.93	0.001
465	0.96	0.002
460	1.02	0.002
455	1.06	0.001
450	1.10	0.002
445	1.14	0.001
440	1.21	0.002
435	1.26	0.002
430	1.32	0.002

Table A3, continued.

Wavelength (nm)	Apparent α (μm^{-1})	Intercept
425	1.38	0.002
420	1.47	0.002
415	1.53	0.002
410	1.63	0.003
405	1.72	0.002
400	1.80	0.002
395	1.91	0.002
390	2.02	0.003
385	2.16	0.002
380	2.28	0.003
375	2.45	0.003
370	2.59	0.002
365	2.73	0.003
360	2.94	0.003
355	3.13	0.003

Table A4. Beer's law fit results for the bisphenol photodeposit, ultraviolet wavelength range.

Wavelength	Apparent α (μm^{-1})	Intercept (see plots)
395.0	1.98	0.005
392.5	1.99	0.004
390.0	2.07	0.003
387.5	2.19	0.004
385.0	2.26	0.002
382.5	2.25	0.001

Table A4, continued

Wavelength	Apparent α (μm^{-1})	Intercept (see plots)
380.0	2.27	0.001
377.5	2.34	0.000
375.0	2.44	0.000
372.5	2.56	0.001
370.0	2.66	0.001
367.5	2.74	0.002
365.0	2.82	0.004
362.5	2.93	0.004
360.0	3.04	0.004
357.5	3.12	0.004
355.0	3.21	0.004
352.5	3.34	0.005
350.0	3.45	0.006
347.5	3.52	0.006
345.0	3.58	0.005
342.5	3.71	0.004
340.0	3.84	0.003
337.5	3.99	0.003
335.0	4.14	0.003
332.5	4.34	0.003
330.0	4.48	0.003
327.5	4.60	0.002
325.0	4.71	0.001
322.5	4.90	0.002
320.0	5.06	0.003
317.5	5.27	0.002
315.0	5.46	0.001

Table A4, continued

Wavelength	Apparent α (μm^{-1})	Intercept (see plots)
312.5	5.66	0.002
310.0	5.87	0.002
307.5	6.07	0.001
305.0	6.28	0.001
302.5	6.50	0.000
300.0	6.74	-0.001
297.7	7.01	-0.001
295.3	7.24	-0.003
293.0	7.43	-0.004
290.6	7.66	-0.006
288.2	7.86	-0.009
285.9	8.04	-0.009
283.6	8.18	-0.010
281.2	8.30	-0.011
278.9	8.43	-0.012
276.5	8.62	-0.012
274.1	8.86	-0.011
271.8	9.10	-0.011
269.4	9.35	-0.011
267.1	9.59	-0.011
264.7	9.82	-0.011
262.4	10.06	-0.013
260.0	10.31	-0.015
257.7	10.55	-0.017
255.3	10.79	-0.020
253.0	11.08	-0.023
250.6	11.37	-0.026

Table A4, continued

Wavelength	Apparent α (μm^{-1})	Intercept (see plots)
248.3	11.72	-0.029
245.9	12.10	-0.033
243.6	12.56	-0.038
241.2	13.06	-0.044
238.8	13.59	-0.050

Table A5. Apparent absorption coefficients from the constrained fits, visible wavelengths.

Wavelength (nm)	Apparent α (μm^{-1})
695	0.17
690	0.17
685	0.19
680	0.31
675	0.30
670	0.24
665	0.24
660	0.27
655	0.30
650	0.30
645	0.35
640	0.30
635	0.32
630	0.30
625	0.32
620	0.32
615	0.33
610	0.36

Table A5, continued

Wavelength (nm)	Apparent α (μm^{-1})
605	0.35
600	0.36
595	0.34
590	0.35
585	0.36
580	0.37
575	0.38
570	0.39
565	0.40
560	0.42
555	0.44
550	0.45
545	0.45
540	0.49
535	0.52
530	0.50
525	0.51
520	0.55
515	0.59
510	0.57
505	0.63
500	0.64
495	0.67
490	0.69
485	0.71
480	0.76
475	0.76

Table A5, continued

Wavelength (nm)	Apparent α (μm^{-1})
470	0.83
465	0.81
460	0.88
455	0.93
450	0.96
445	1.02
440	1.04
435	1.09
430	1.16
425	1.20
420	1.27
415	1.36
410	1.39
405	1.53
400	1.58
395	1.71
390	1.78
385	1.94
380	2.04
375	2.22
370	2.39
365	2.45
360	2.69
355	2.85

Table A6. Apparent absorption coefficients from the constrained fits, ultraviolet wavelengths.

Wavelength (nm)	Apparent α (μm^{-1})
395.0	1.58
392.5	1.65
390.0	1.82
387.5	1.85
385.0	2.08
382.5	2.20
380.0	2.21
377.5	2.26
375.0	2.35
372.5	2.44
370.0	2.48
367.5	2.53
365.0	2.43
362.5	2.50
360.0	2.62
357.5	2.70
355.0	2.83
352.5	2.88
350.0	2.93
347.5	3.06
345.0	3.27
342.5	3.53
340.0	3.73
337.5	3.88
335.0	4.04
332.5	4.14

Table A6, continued

Wavelength (nm)	Apparent α (μm^{-1})
330.0	4.26
327.5	4.43
325.0	4.61
322.5	4.74
320.0	4.84
317.5	5.11
315.0	5.39
312.5	5.59
310.0	5.82
307.5	6.07
305.0	6.32
302.5	6.62
300.0	6.89
297.7	7.21
295.3	7.56
293.0	7.91
290.6	8.33
288.2	8.75
285.9	8.97
283.6	9.17
281.2	9.46
278.9	9.68
276.5	9.90
274.1	10.04
271.8	10.22
269.4	10.41
267.1	10.66

Table A6, continued

Wavelength (nm)	Apparent α (μm^{-1})
264.7	10.94
262.4	11.33
260.0	11.70
257.7	12.16
255.3	12.65
253.0	13.25
250.6	13.79
248.3	14.42
245.9	15.15
243.6	16.04
241.2	17.09

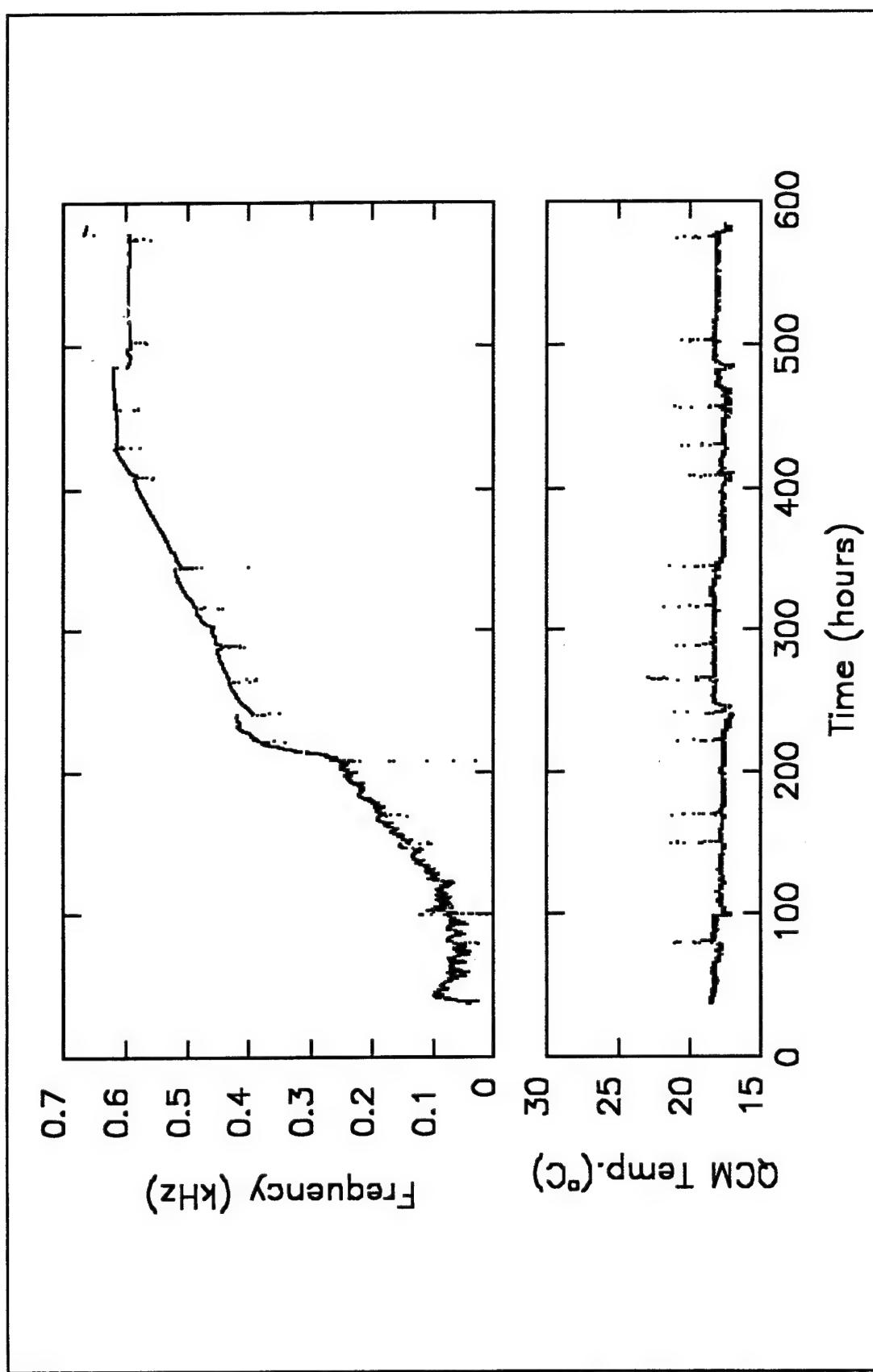


Figure A1 QCM data measured during the photochemical deposition of bisphenol.

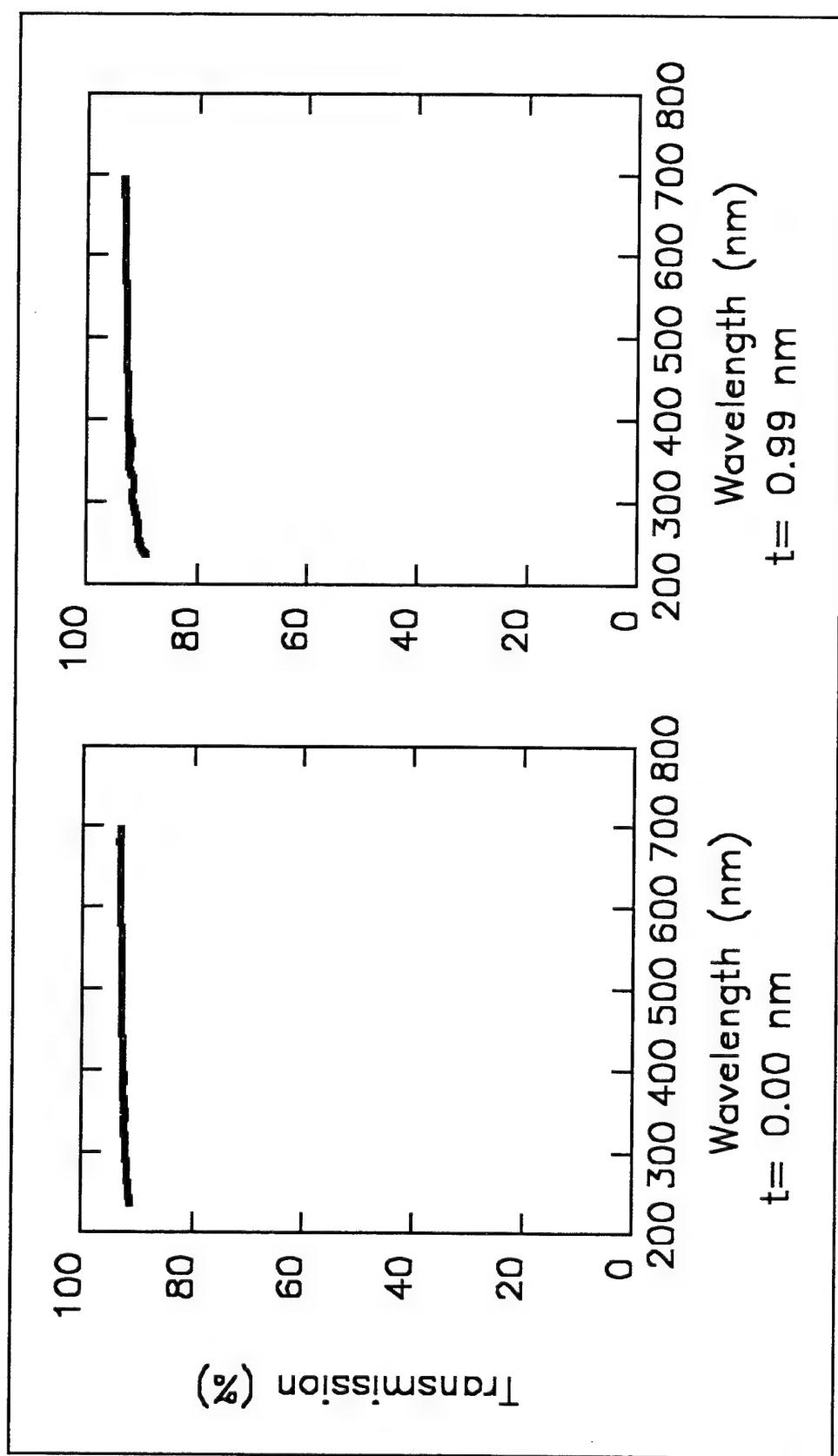


Figure A2 Transmission spectra measured during photodeposition of bishphenol.

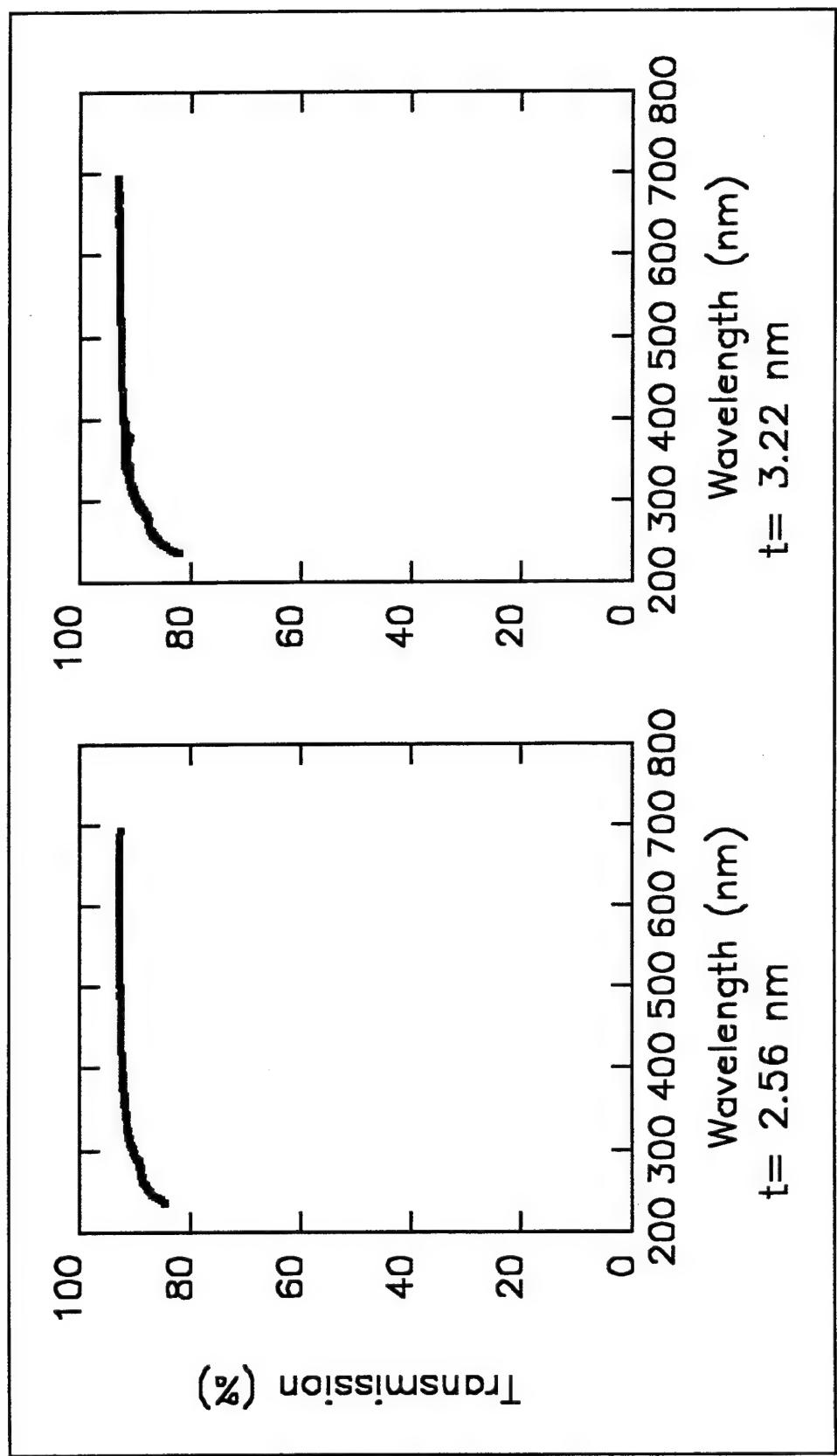


Figure A3 Transmission spectra measured during photodeposition of bisphenol.

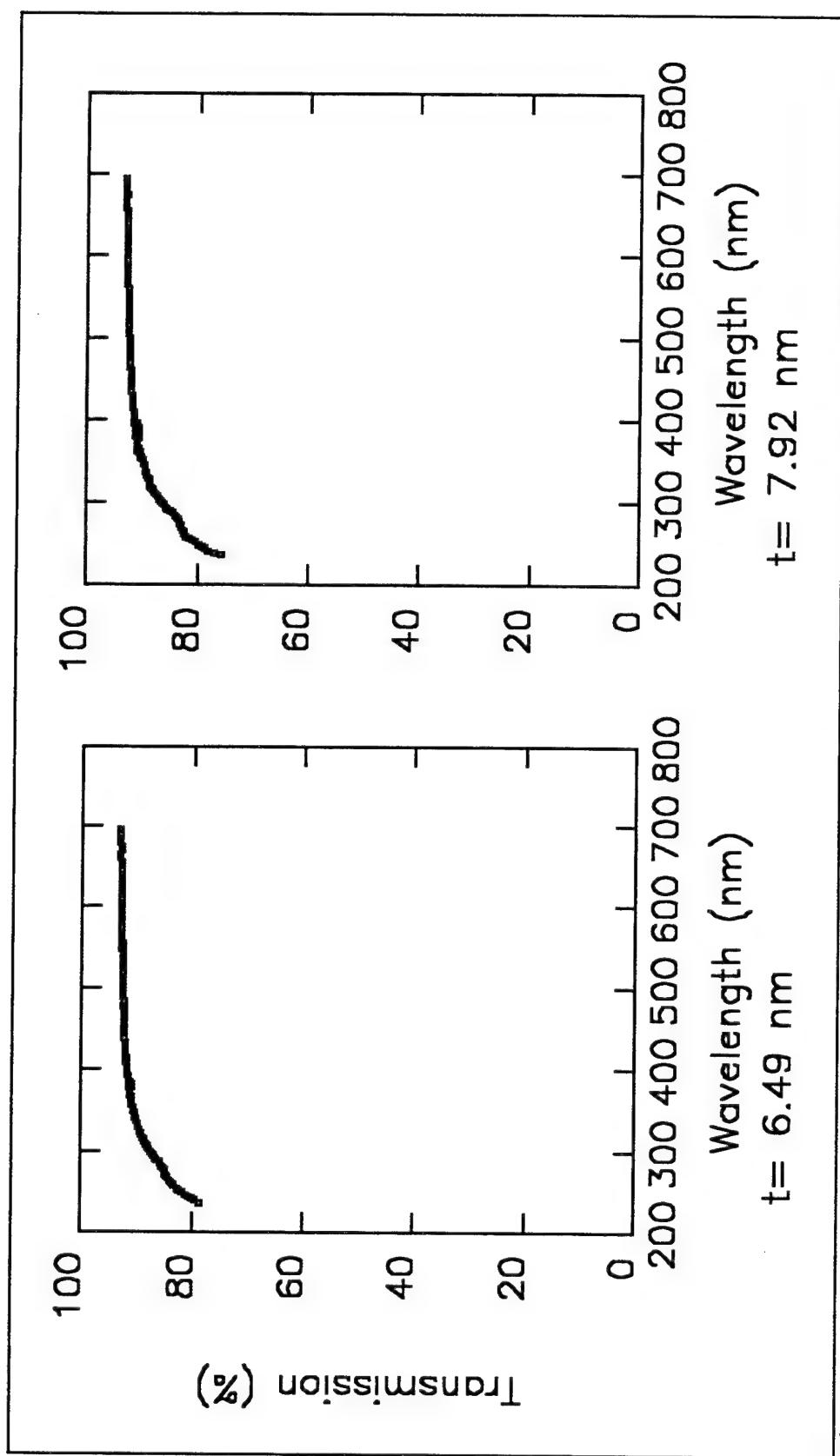


Figure A4 Transmission spectra measured during photodeposition of bisphenol.

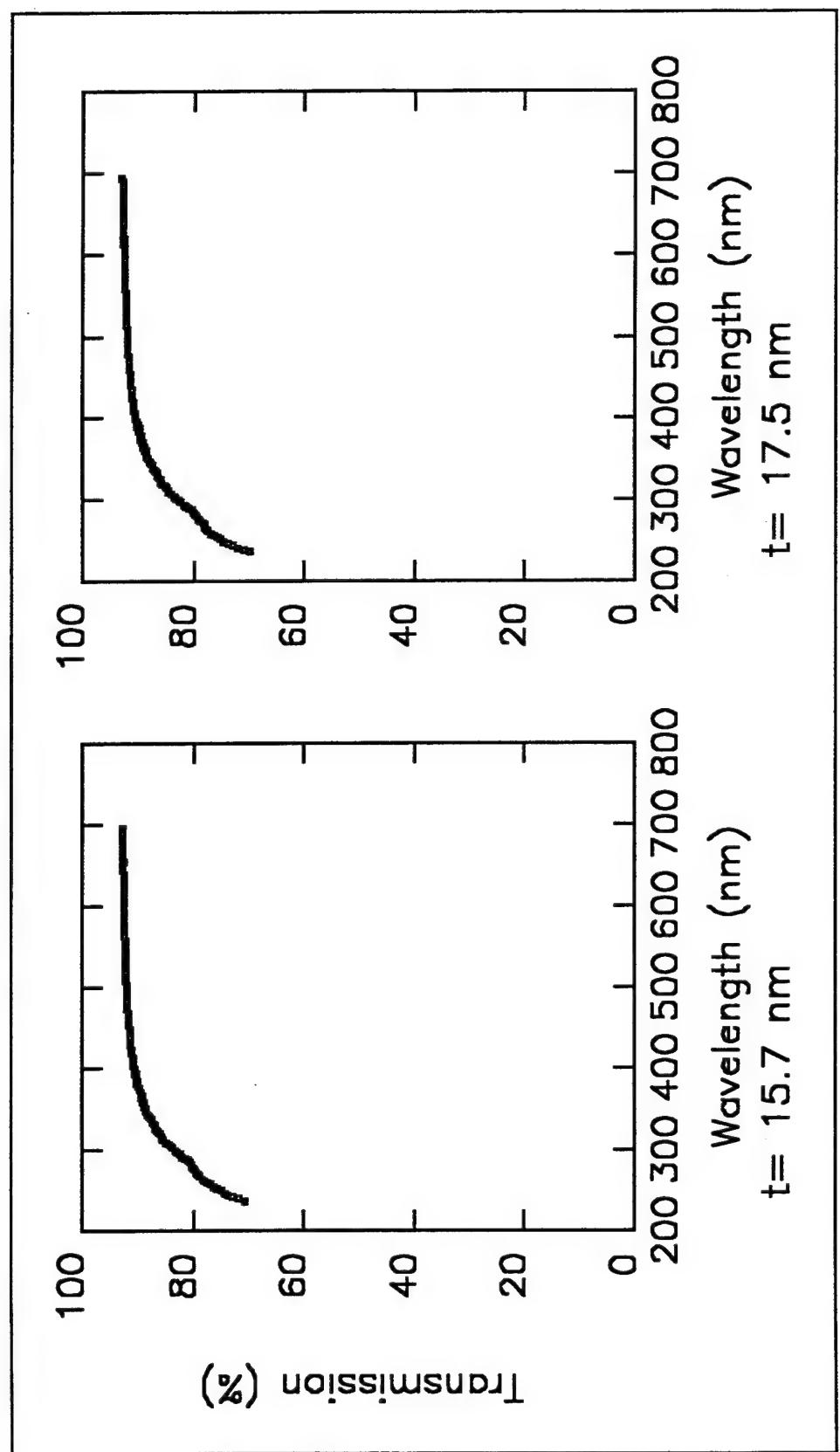


Figure A5 Transmission spectra measured during photodeposition of bisphenol.

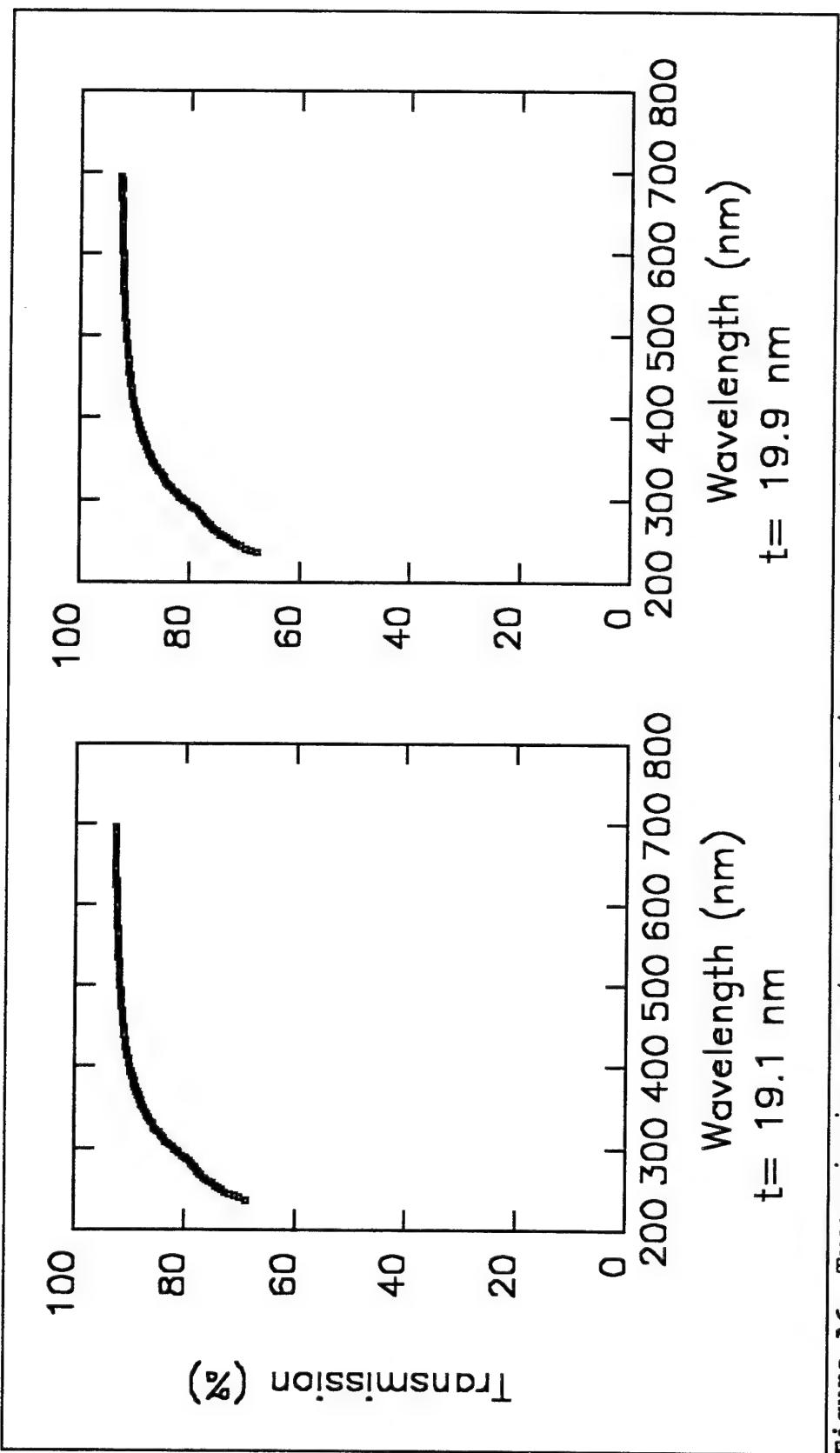


Figure A6 Transmission spectra measured during photodeposition of bisphenol.

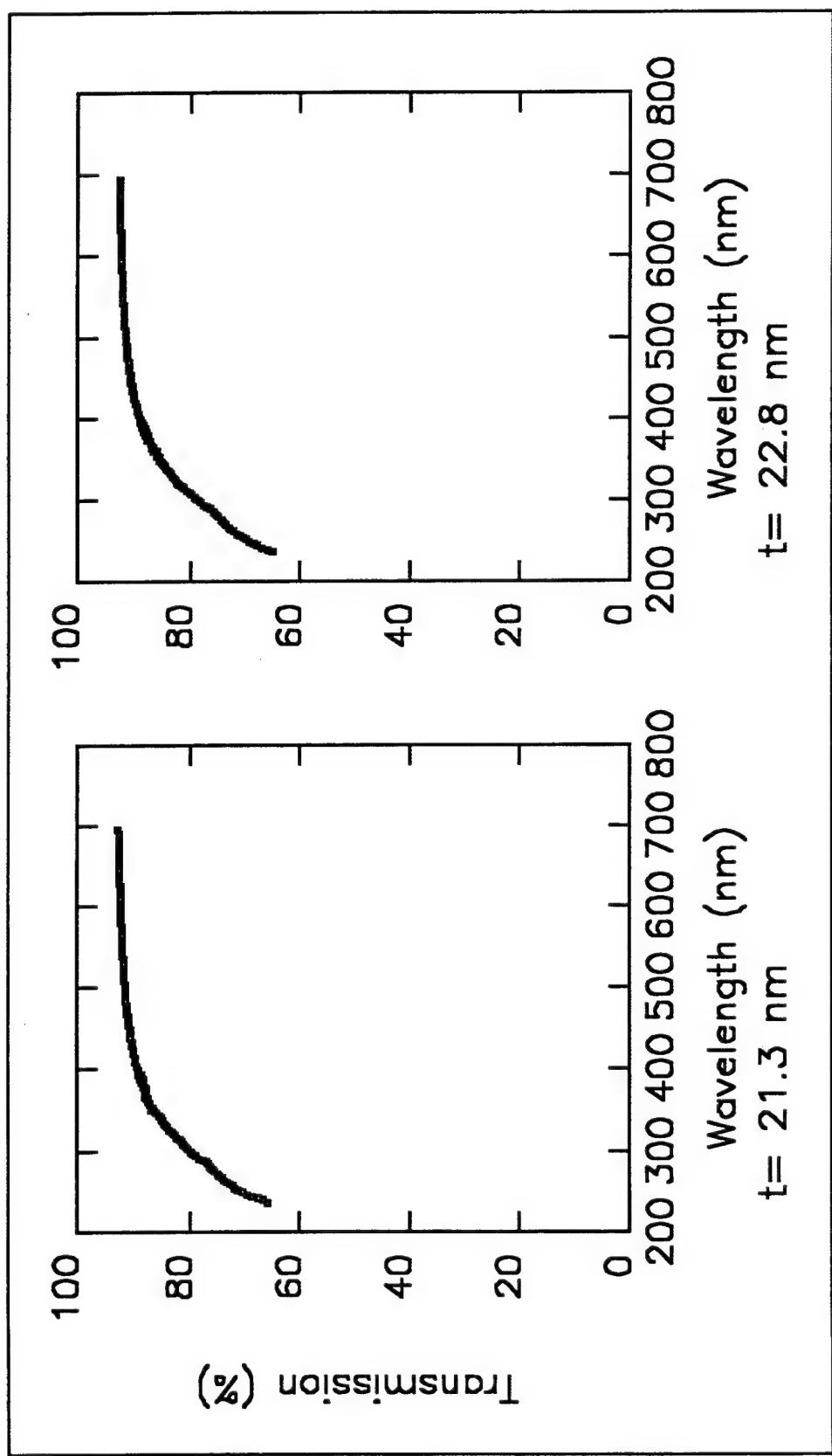


Figure A7 Transmission spectra measured during photodeposition of bisphenol.

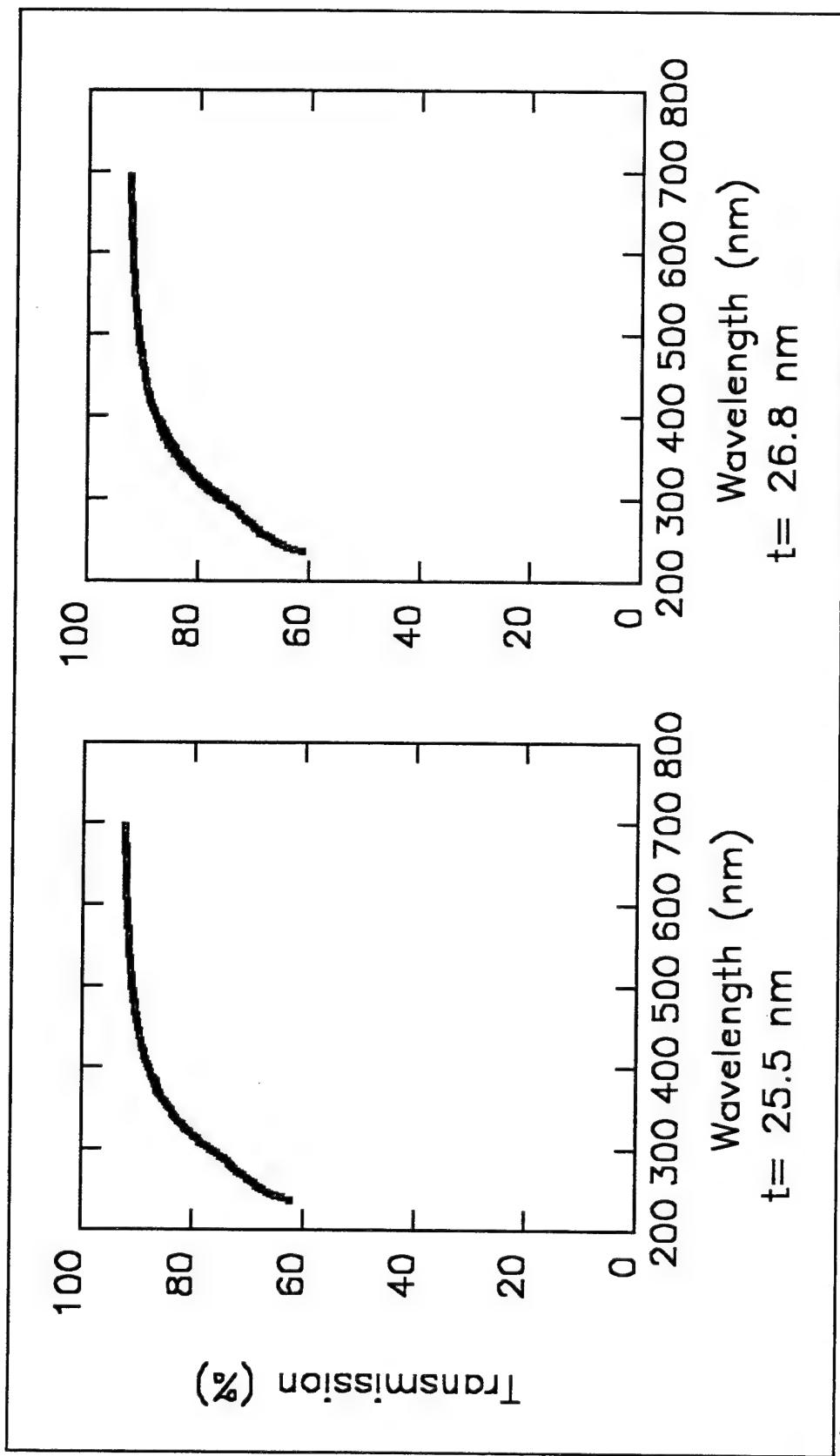


Figure A8 Transmission spectra measured during photodeposition of bisphenol.

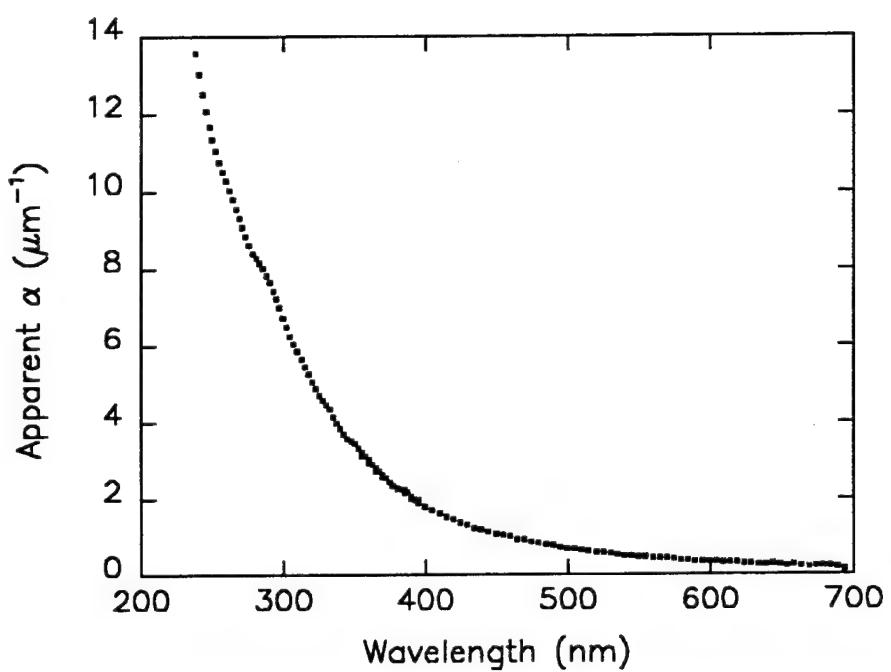


Figure A9. Apparent absorption coefficient obtained from the fits to the Beer-Lambert absorption law. Linear plot

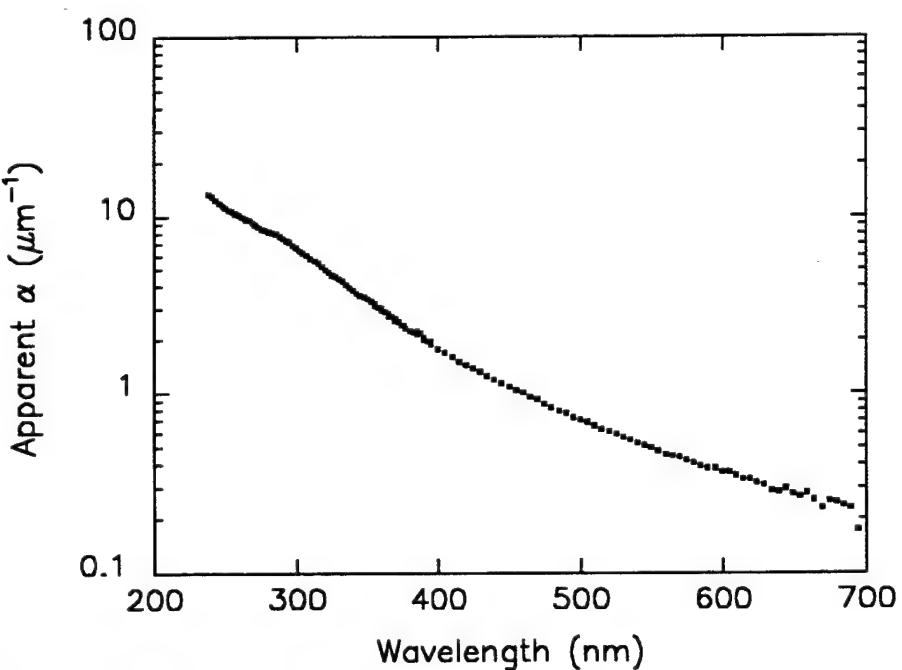


Figure A10. Apparent absorption coefficient obtained from the data fits to the Beer-Lambert absorption law. Log plot

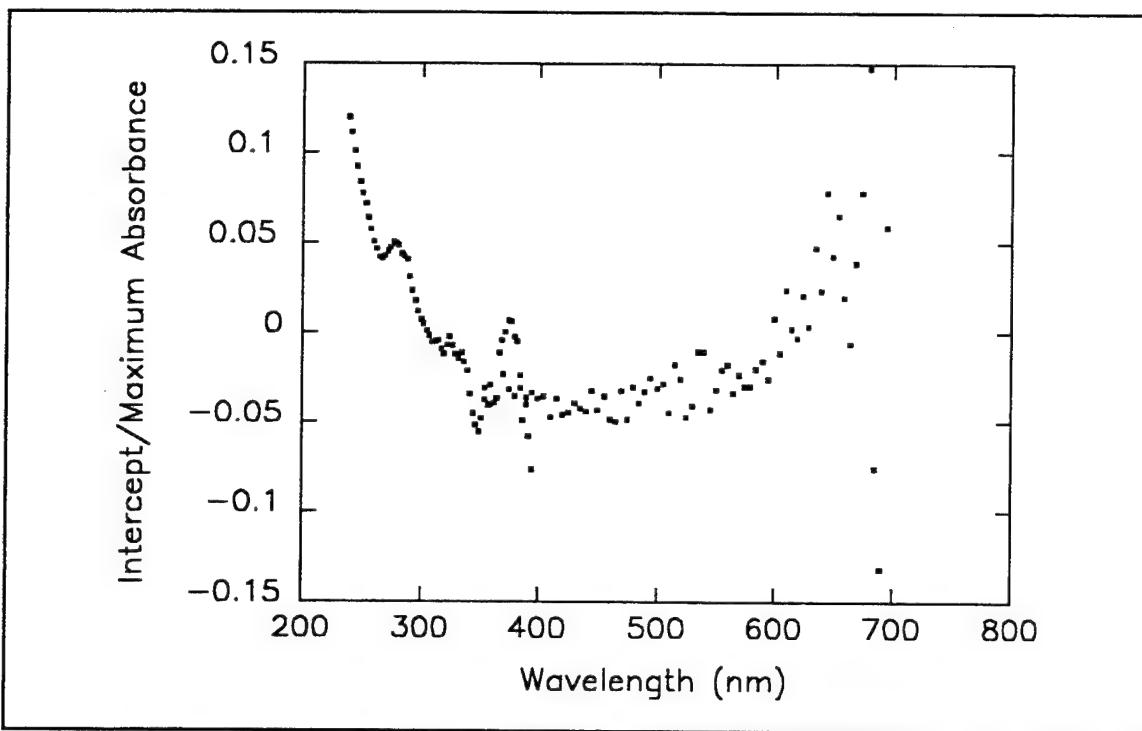


Figure A11 Plot of the ratio fo the intercep of the Beer's law fit to the bisphenol absorption data to the maximum value of the absorbance.

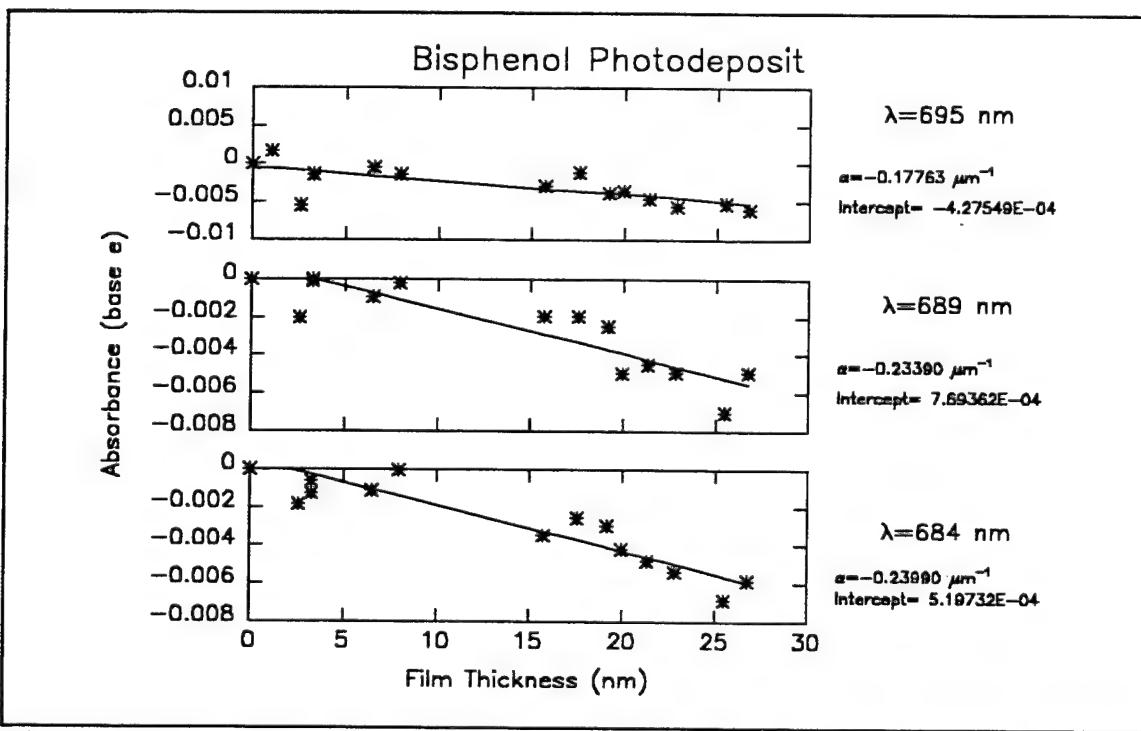


Figure A12a Fits of measured transmission to the Beer-Lambert absorption law. (visible wavelength range)

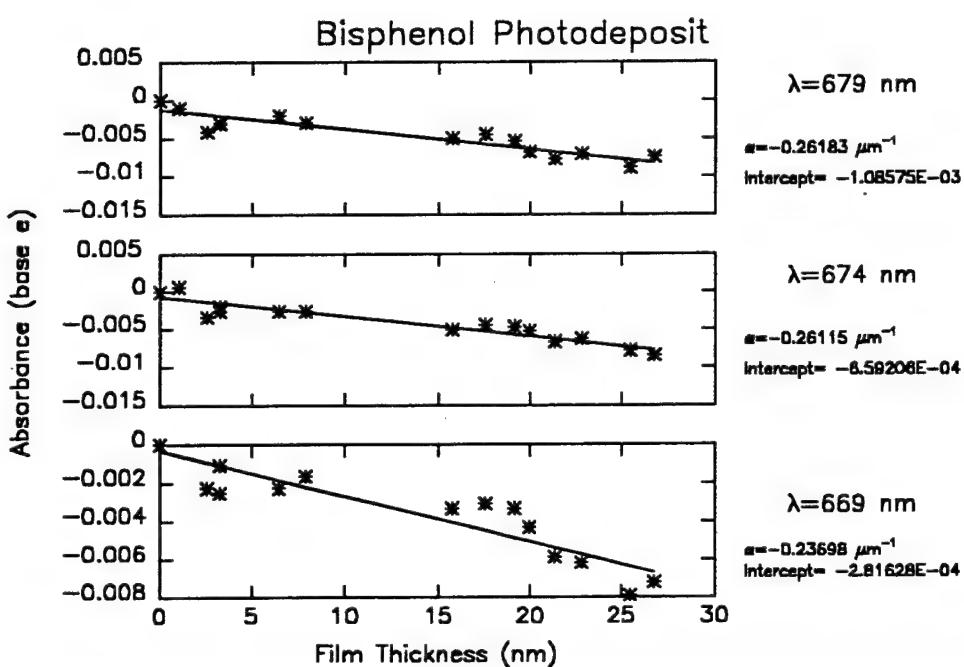


Figure A12b Fits of measured transmission to the Beer-Lambert absorption law. (visible wavelength range)

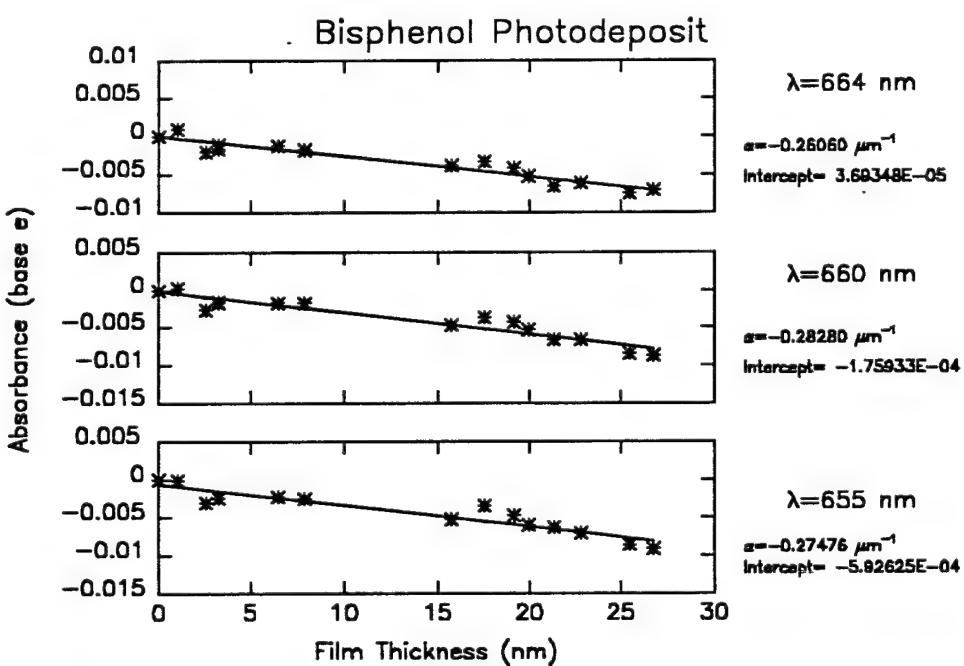


Figure A12c Fits of measured transmission to the Beer-Lambert absorption law. (visible wavelength range)

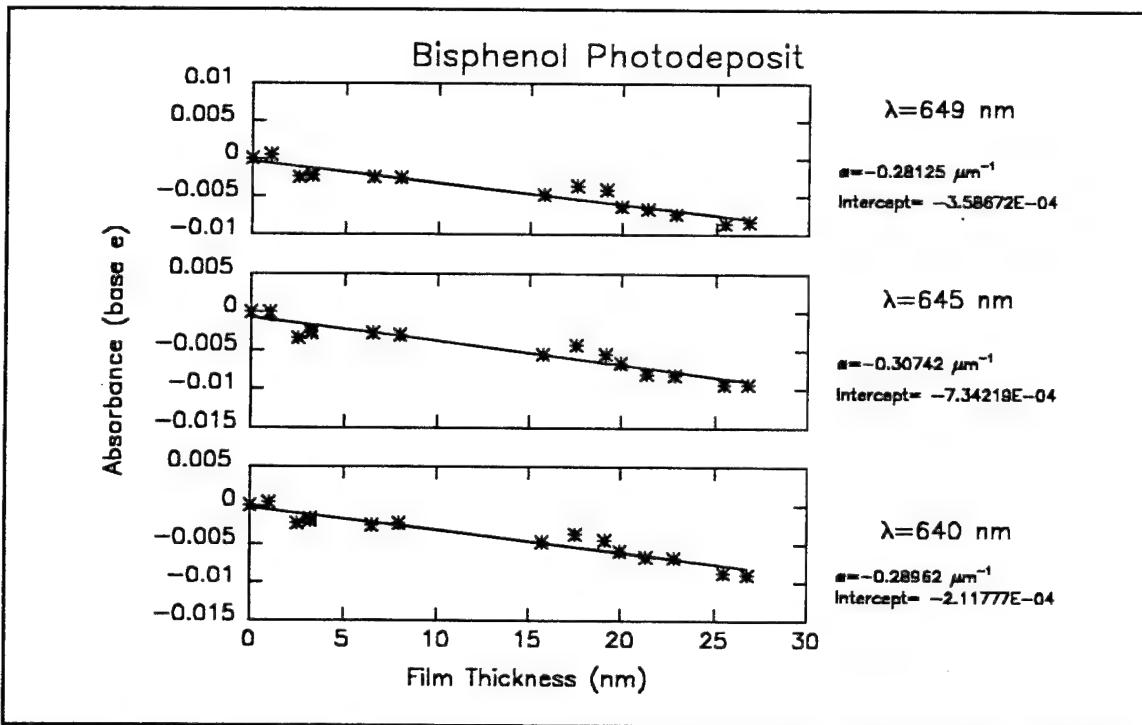


Figure A12d Fits of measured transmission to the Beer-Lambert absorption law. (visible wavelength range)

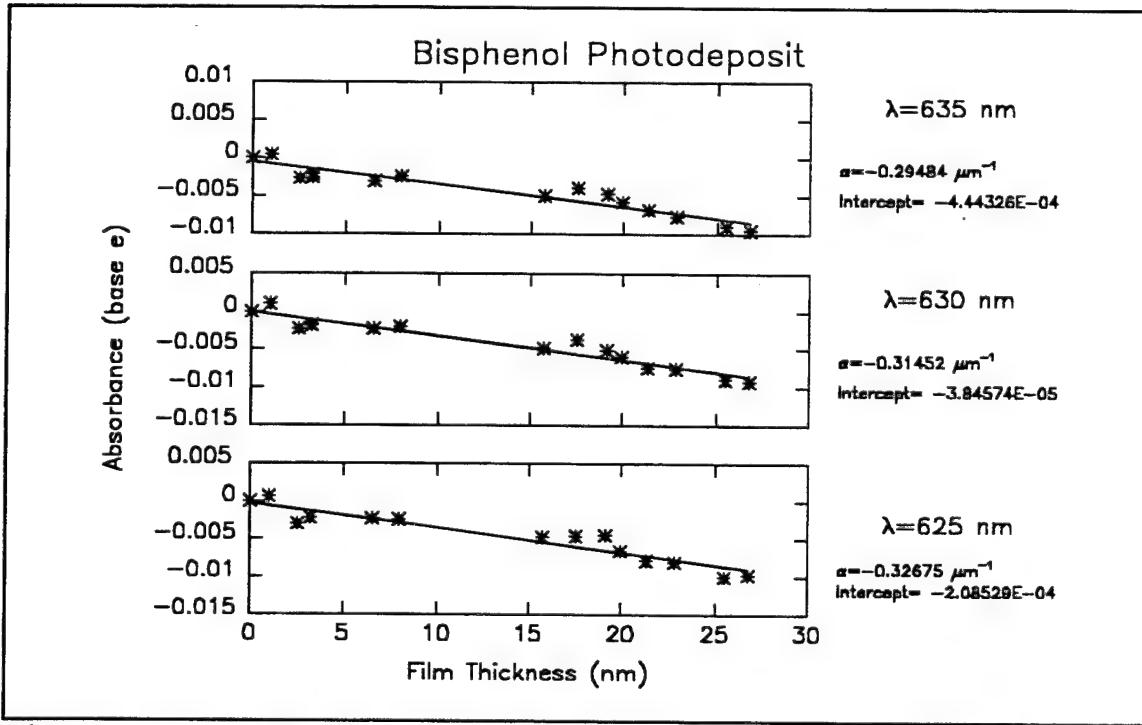


Figure A12e Fits of measured transmission to the Beer-Lambert absorption law. (visible wavelength range)

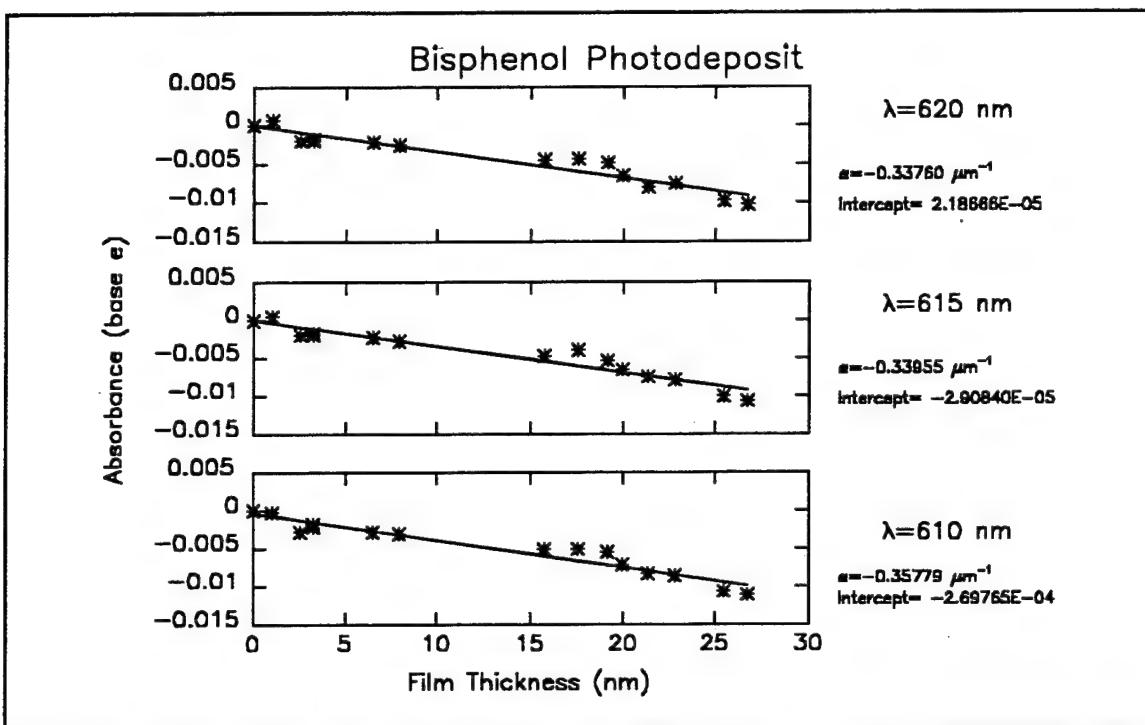


Figure A12f Fits of measured transmission to the Beer-Lambert absorption law. (visible wavelength range)

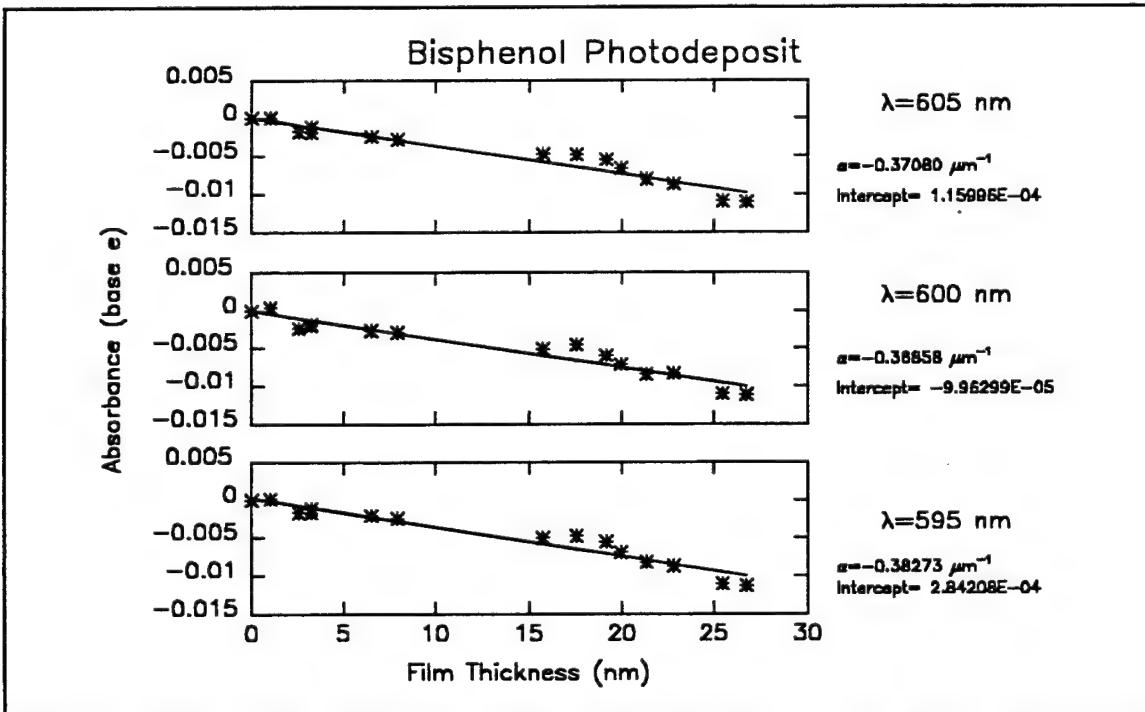


Figure A12g Fits of measured transmission to the Beer-Lambert absorption law. (visible wavelength range)

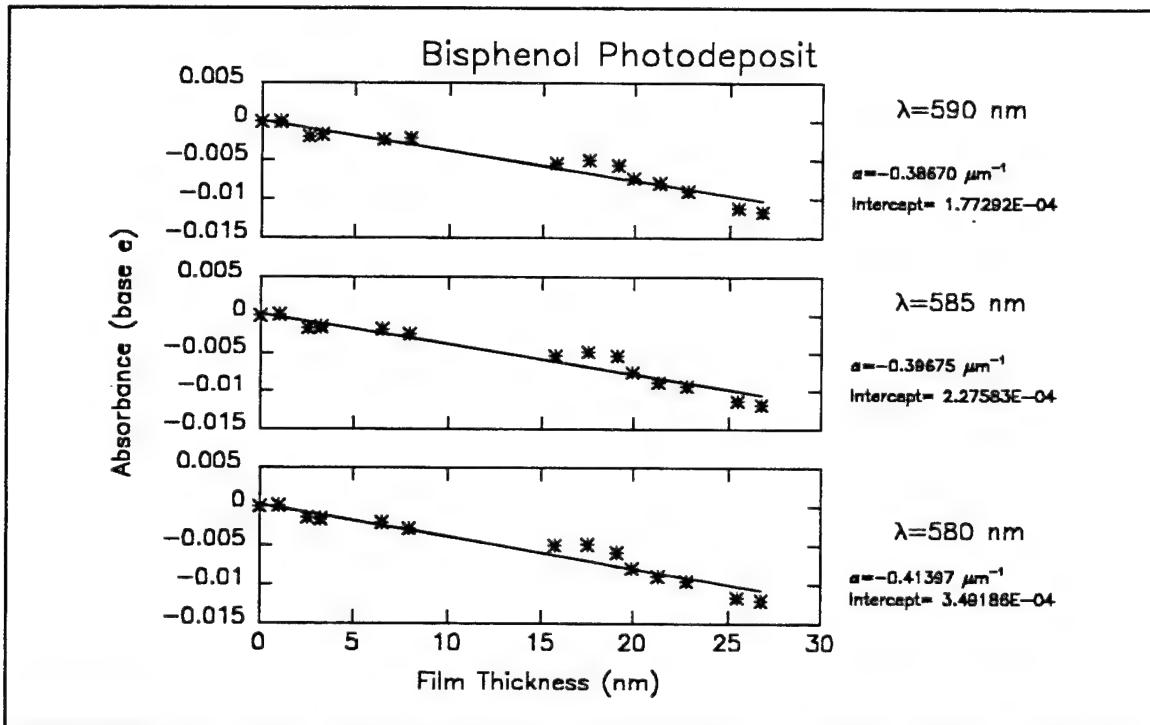


Figure A12h Fits of measured transmission to the Beer-Lambert absorption law. (visible wavelength range)

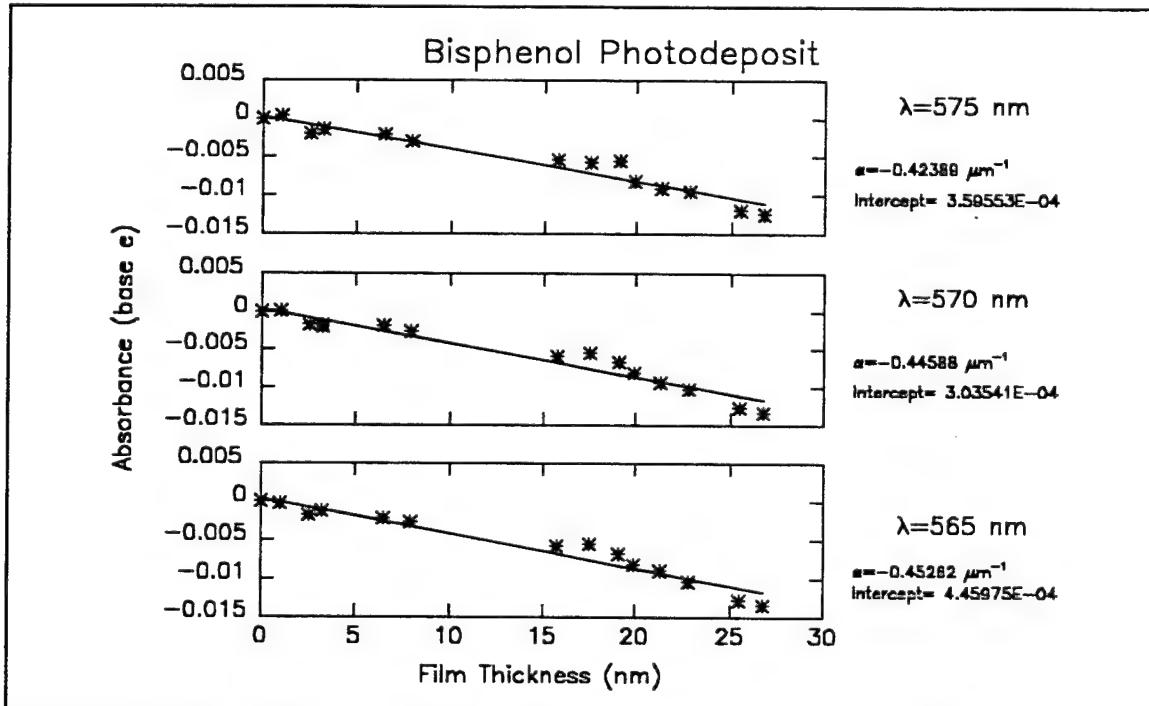


Figure A12i Fits of measured transmission to the Beer-Lambert absorption law. (visible wavelength range)

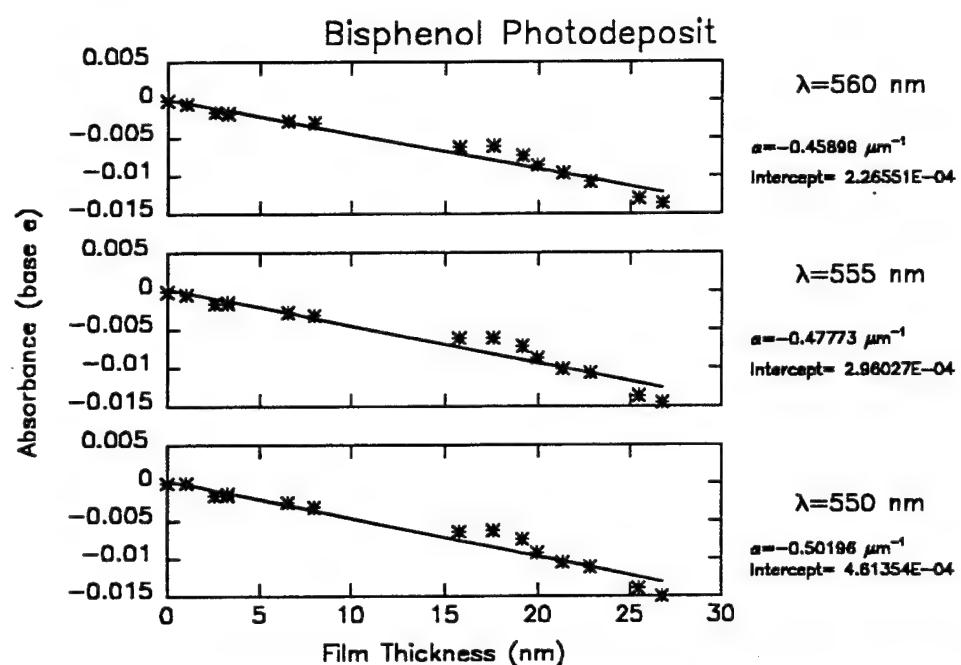


Figure A12j Fits of measured transmission to the Beer-Lambert absorption law. (visible wavelength range)

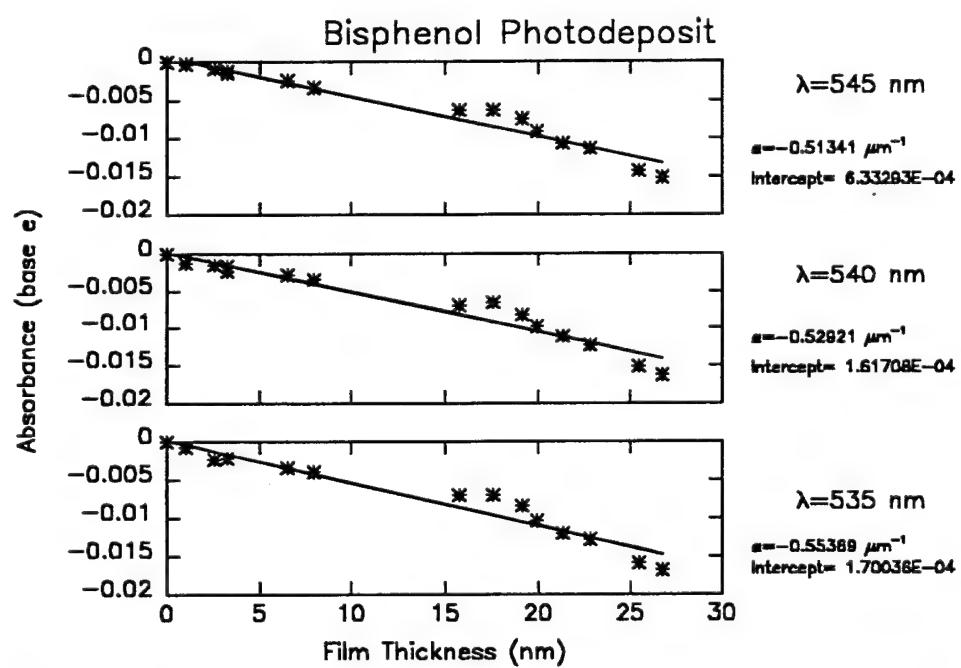


Figure A12k Fits of measured transmission to the Beer-Lambert absorption law. (visible wavelength range)

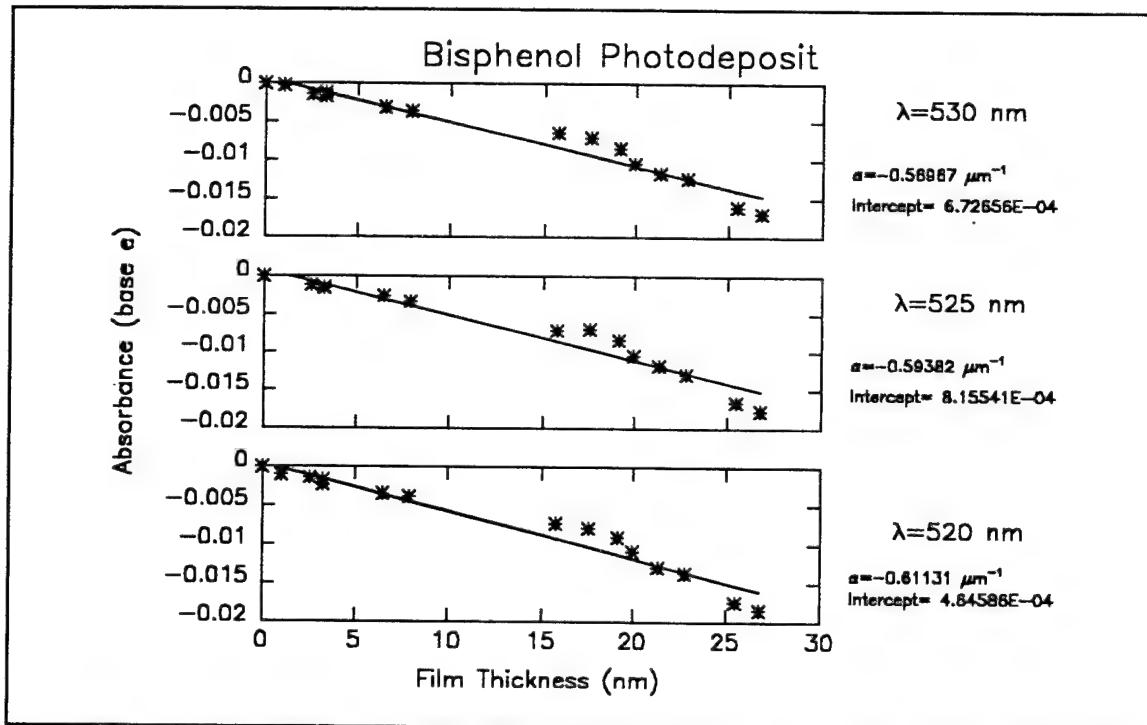


Figure A12l Fits of measured transmission to the Beer-Lambert absorption law. (visible wavelength range)

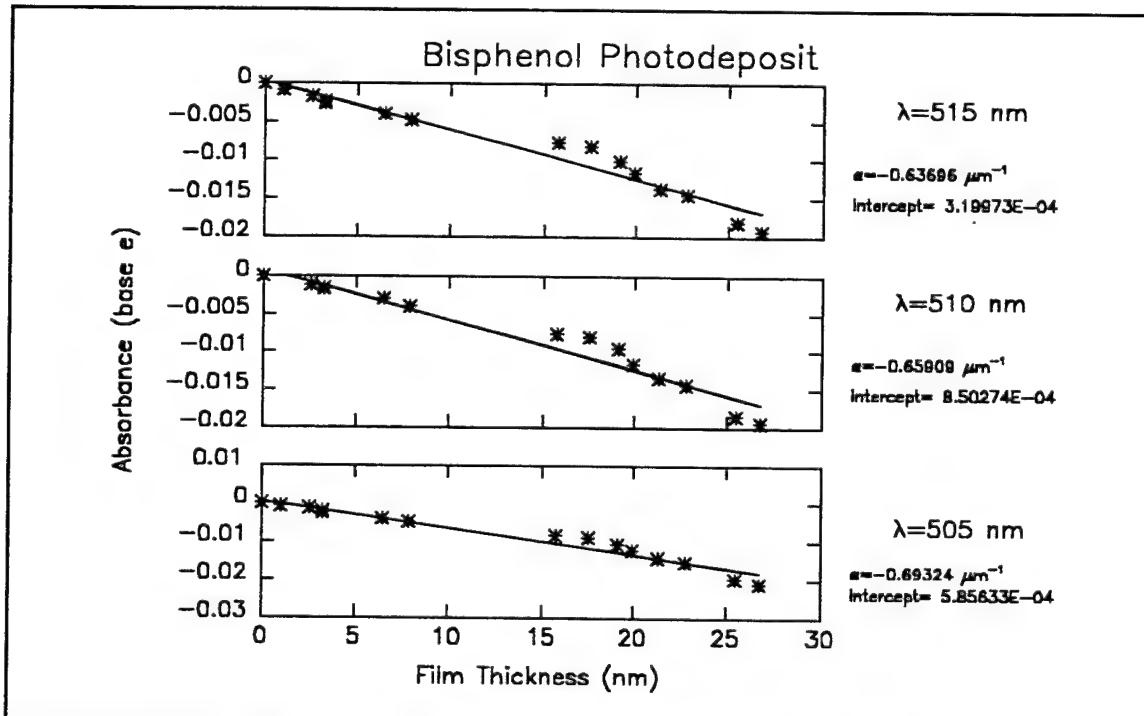


Figure A12m Fits of measured transmission to the Beer-Lambert absorption law. (visible wavelength range)

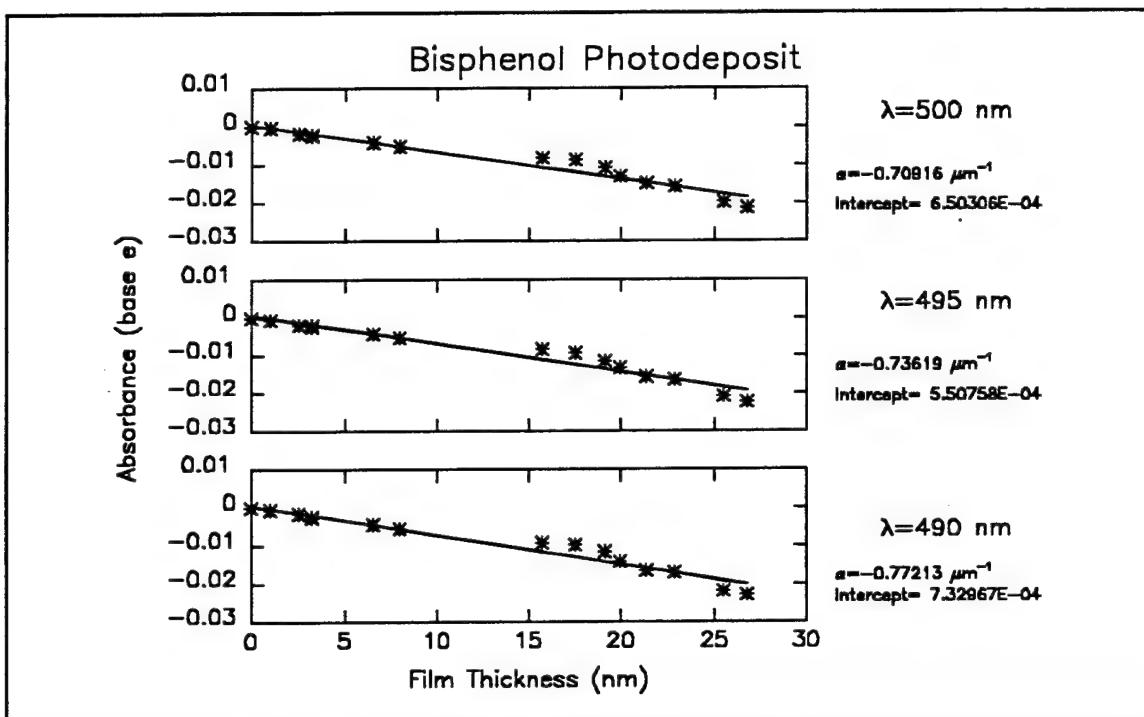


Figure A12n Fits of measured transmission to the Beer-Lambert absorption law. (visible wavelength range)

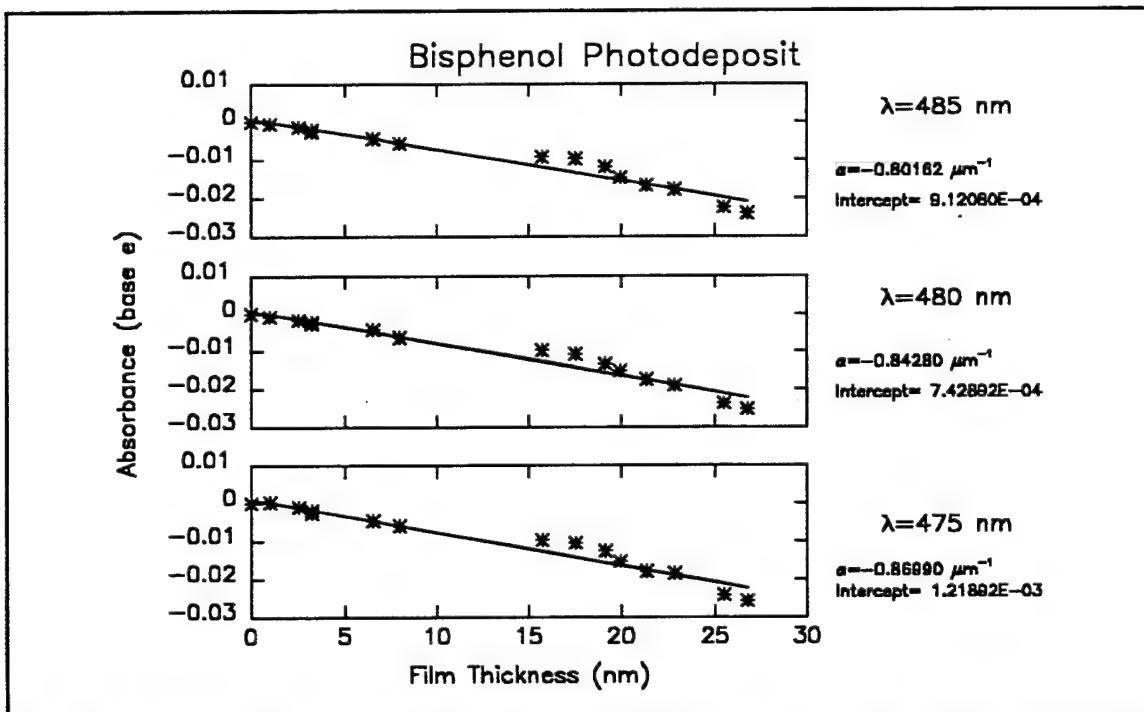


Figure A12o Fits of measured transmission to the Beer-Lambert absorption law. (visible wavelength range)

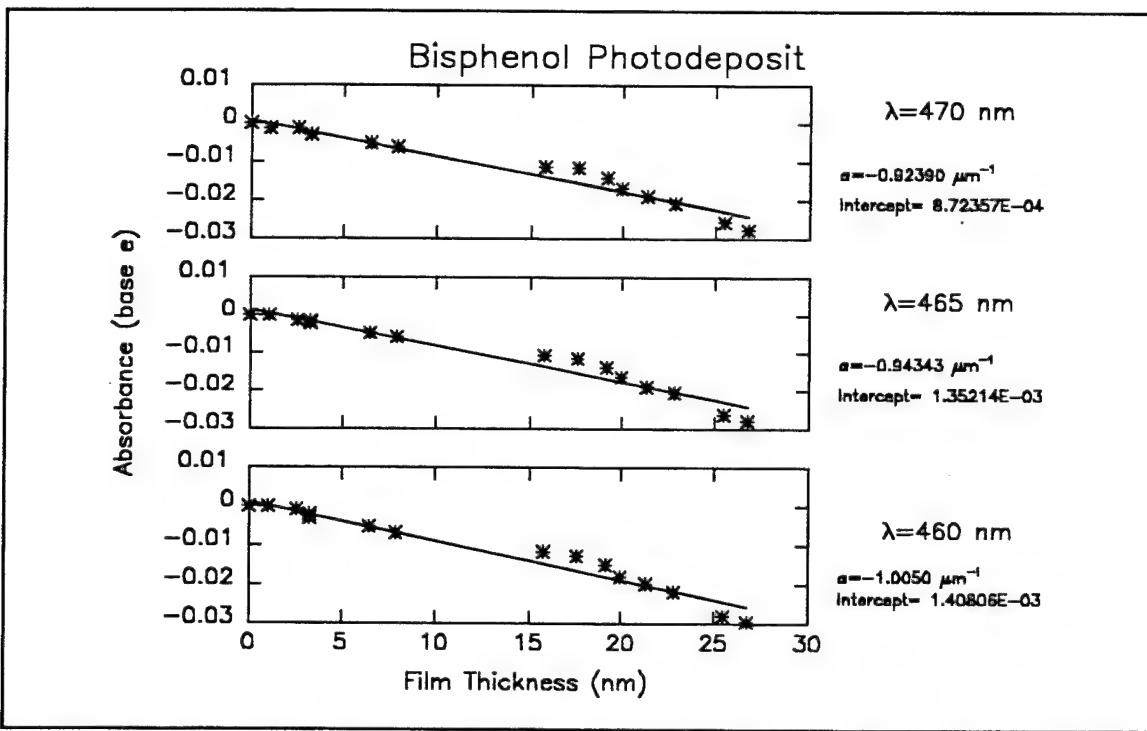


Figure A12p Fits of measured transmission to the Beer-Lambert absorption law. (visible wavelength range)

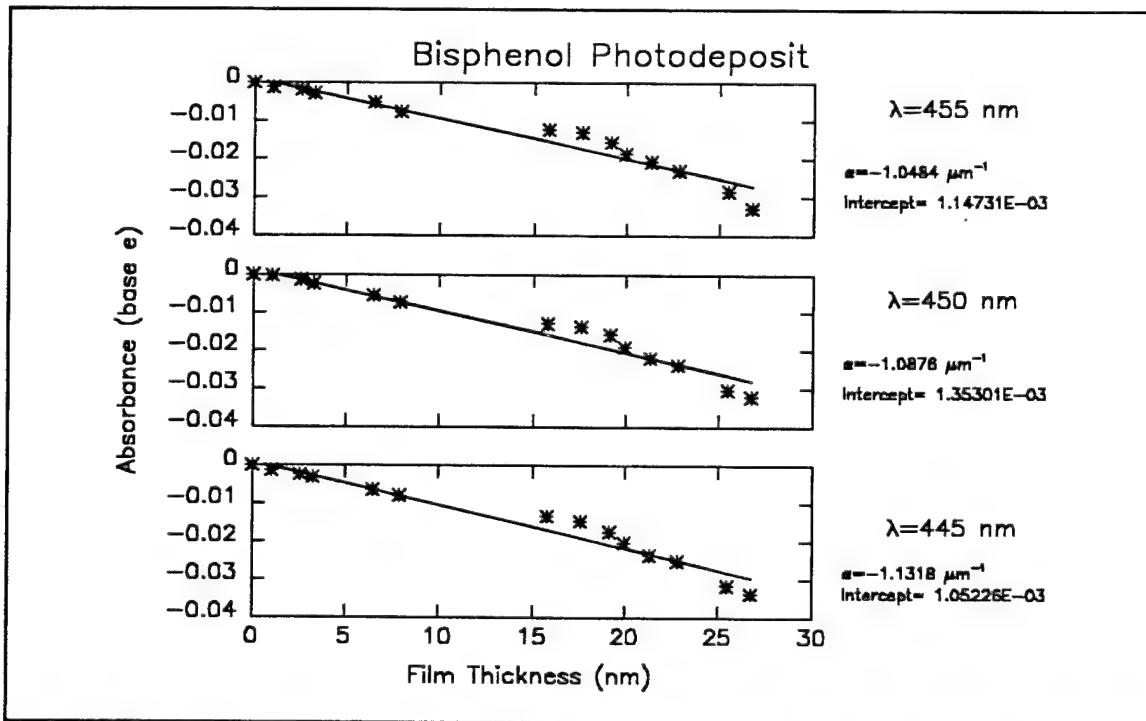


Figure A12q Fits of measured transmission to the Beer-Lambert absorption law. (visible wavelength range)

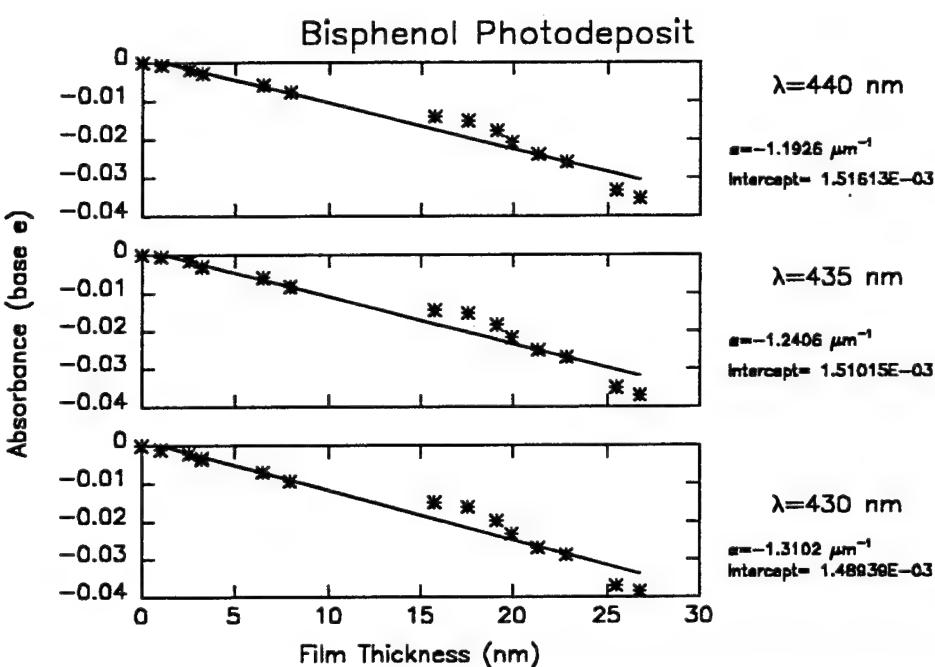


Figure A12r Fits of measured transmission to the Beer-Lambert absorption law. (visible wavelength range)

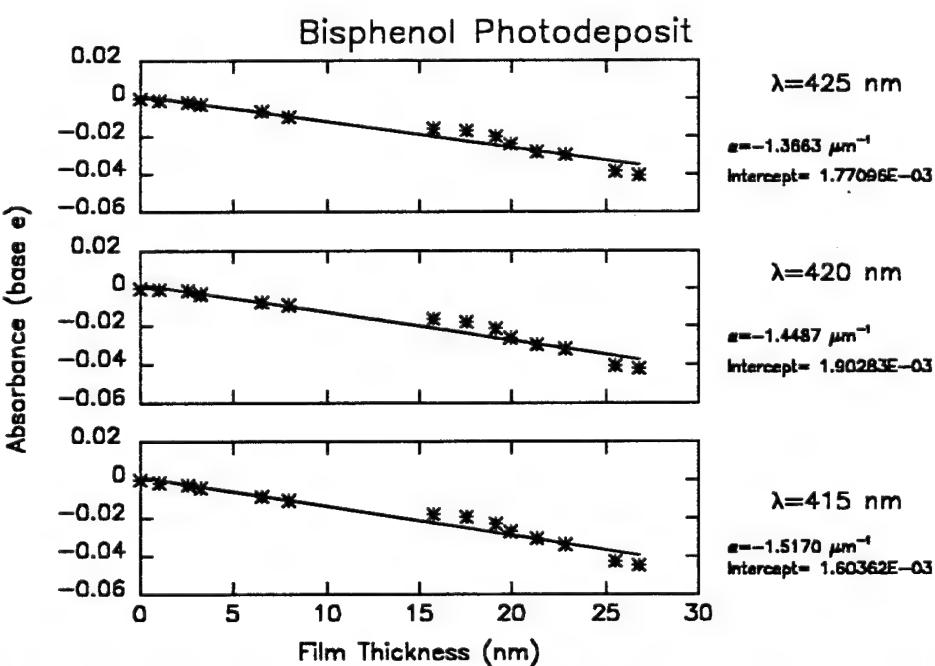


Figure A12s Fits of measured transmission to the Beer-Lambert absorption law. (visible wavelength range)

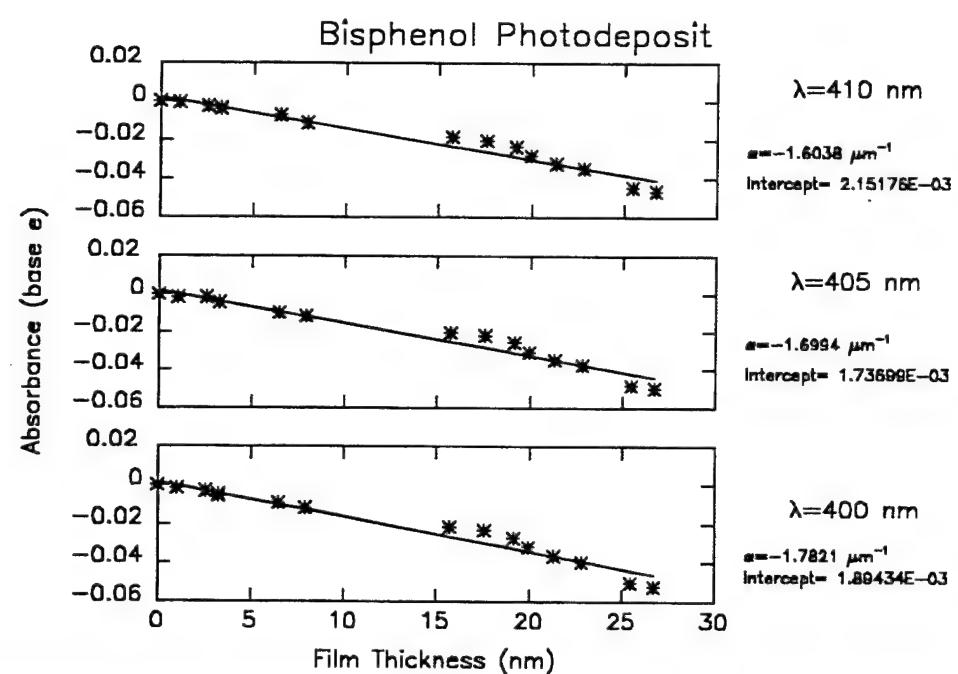


Figure A12t Fits of measured transmission to the Beer-Lambert absorption law. (visible wavelength range)

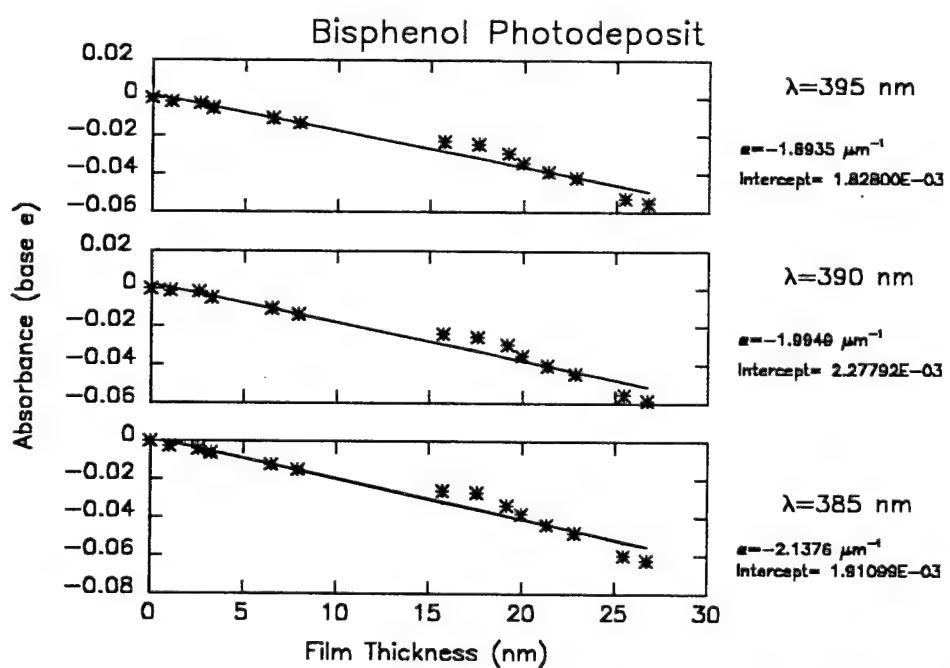


Figure A12u Fits of measured transmission to the Beer-Lambert absorption law. (visible wavelength range)

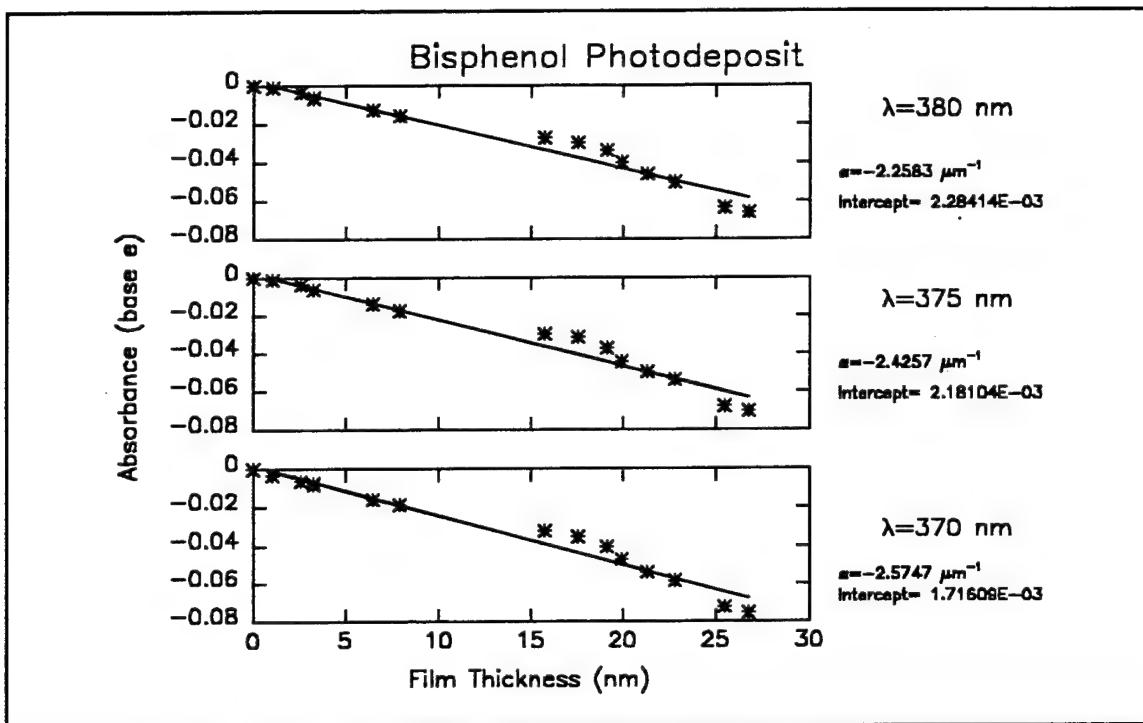


Figure A12v Fits of measured transmission to the Beer-Lambert absorption law. (visible wavelength range)

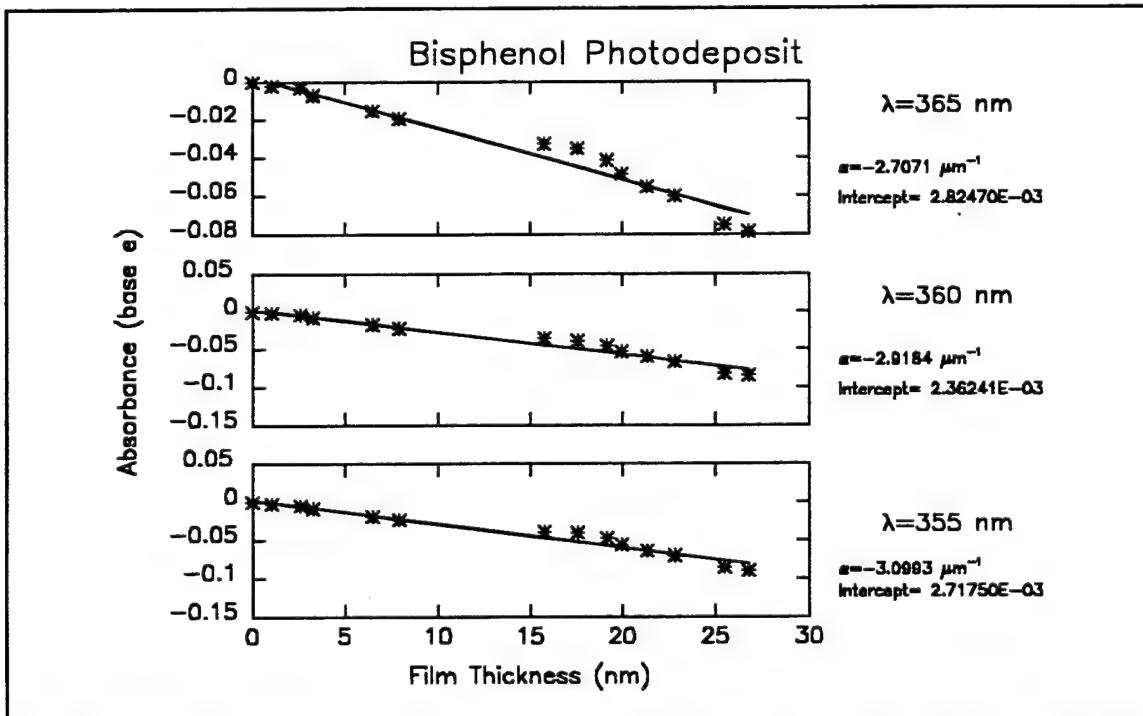


Figure A12w Fits of measured transmission to the Beer-Lambert absorption law. (visible wavelength range)

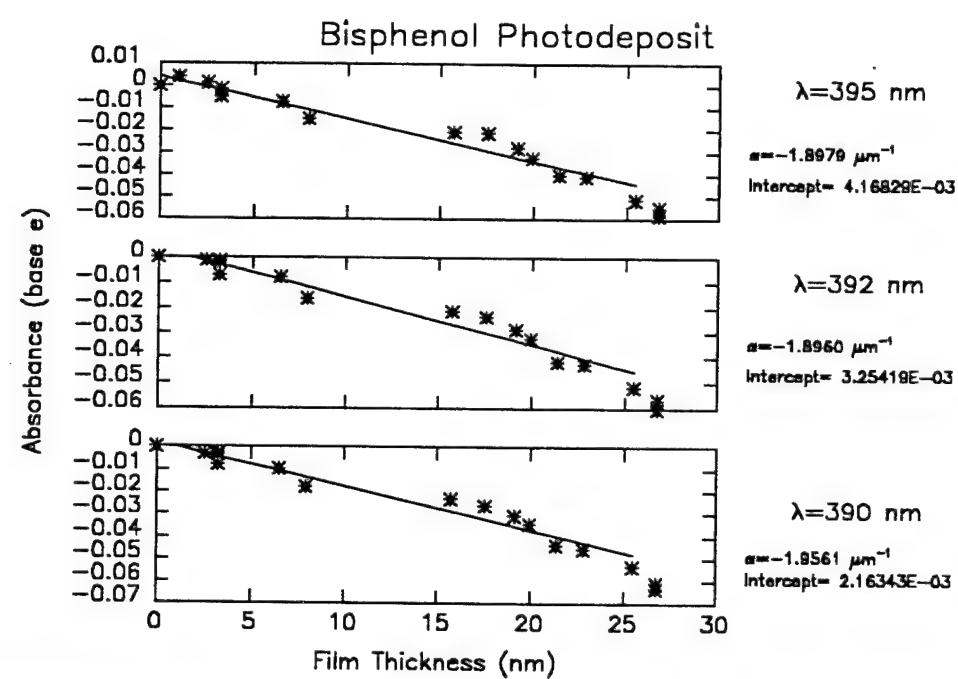


Figure A13a Fits of measured transmission to the Beer-Lambert absorption law. (ultraviolet wavelength range)

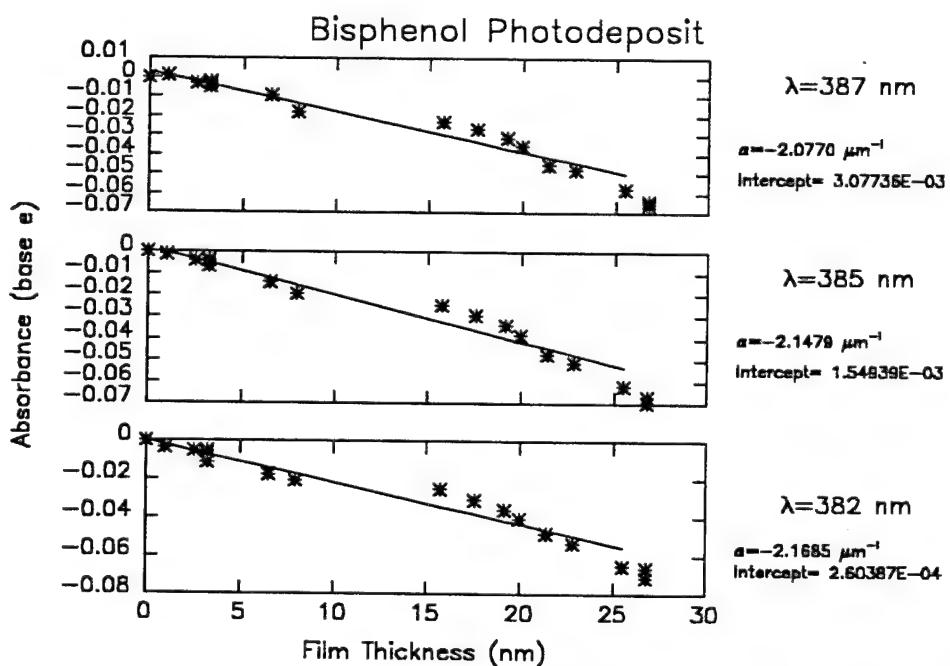


Figure A13b Fits of measured transmission to the Beer-Lambert absorption law. (ultraviolet wavelength range)

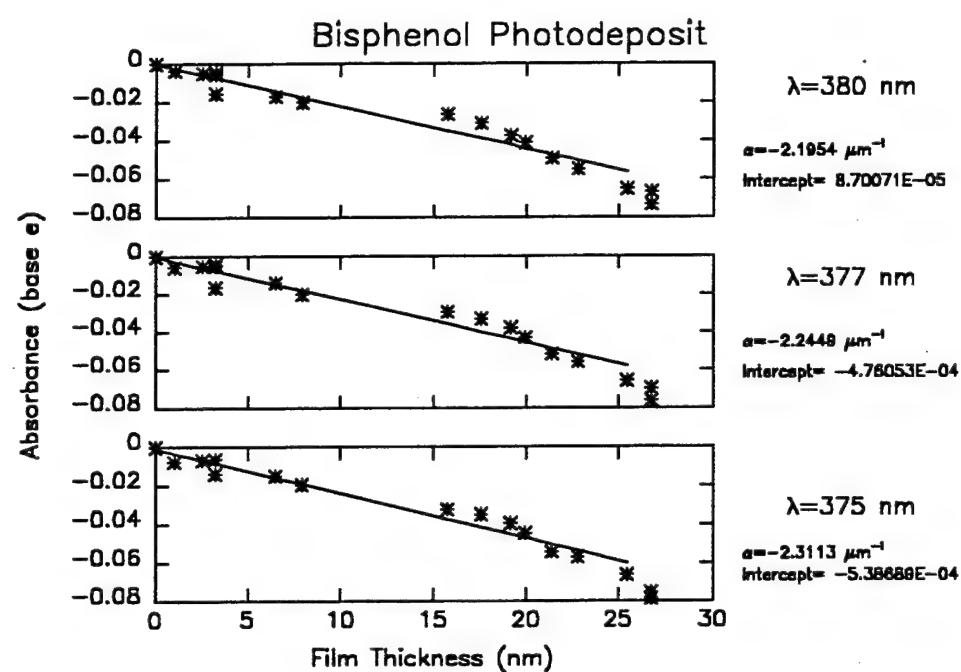


Figure A13c Fits of measured transmission to the Beer-Lambert absorption law. (ultraviolet wavelength range)

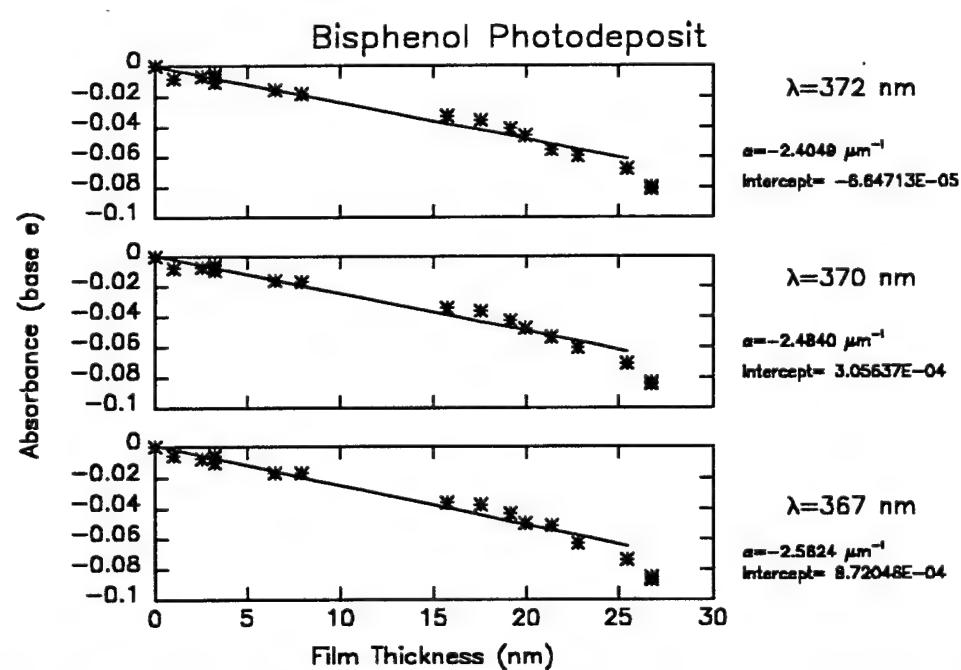


Figure A13d Fits of measured transmission to the Beer-Lambert absorption law. (ultraviolet wavelength range)

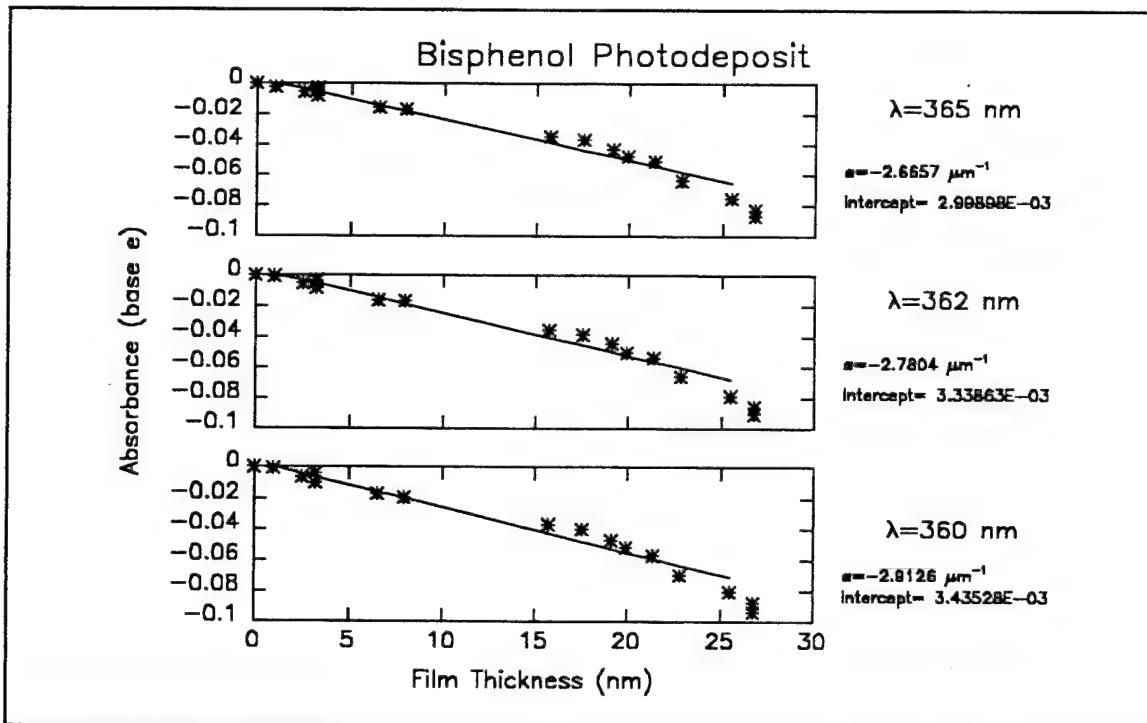


Figure A13e Fits of measured transmission to the Beer-Lambert absorption law. (ultraviolet wavelength range)

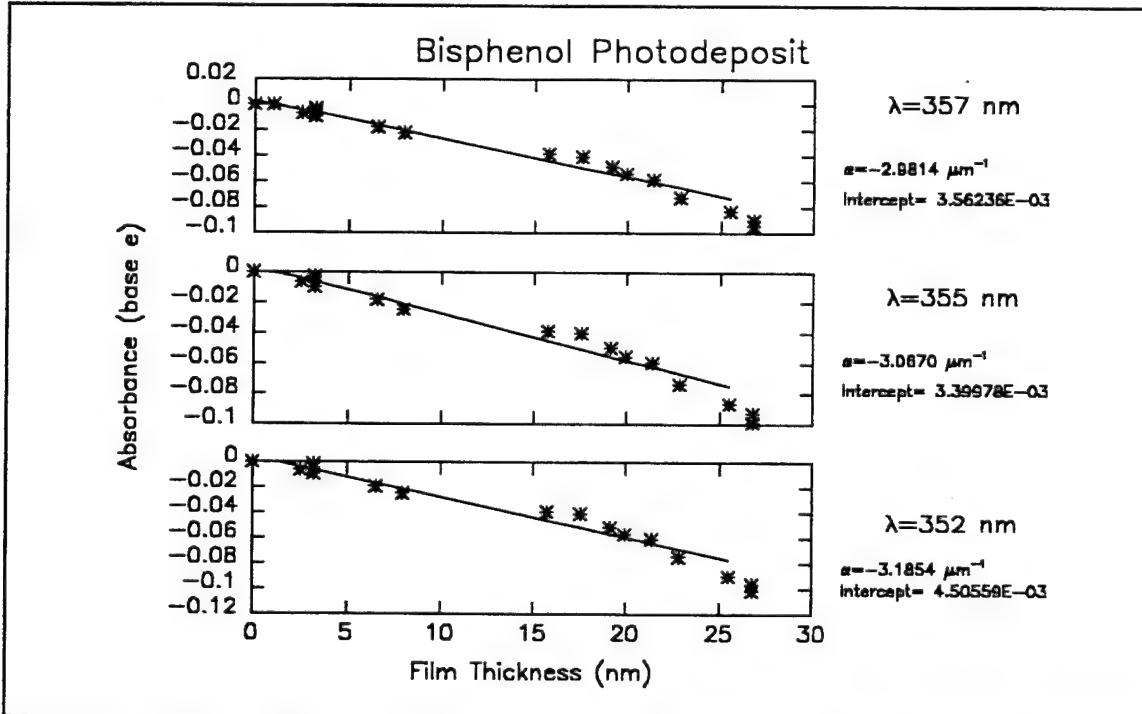


Figure A13f Fits of measured transmission to the Beer-Lambert absorption law. (ultraviolet wavelength range)

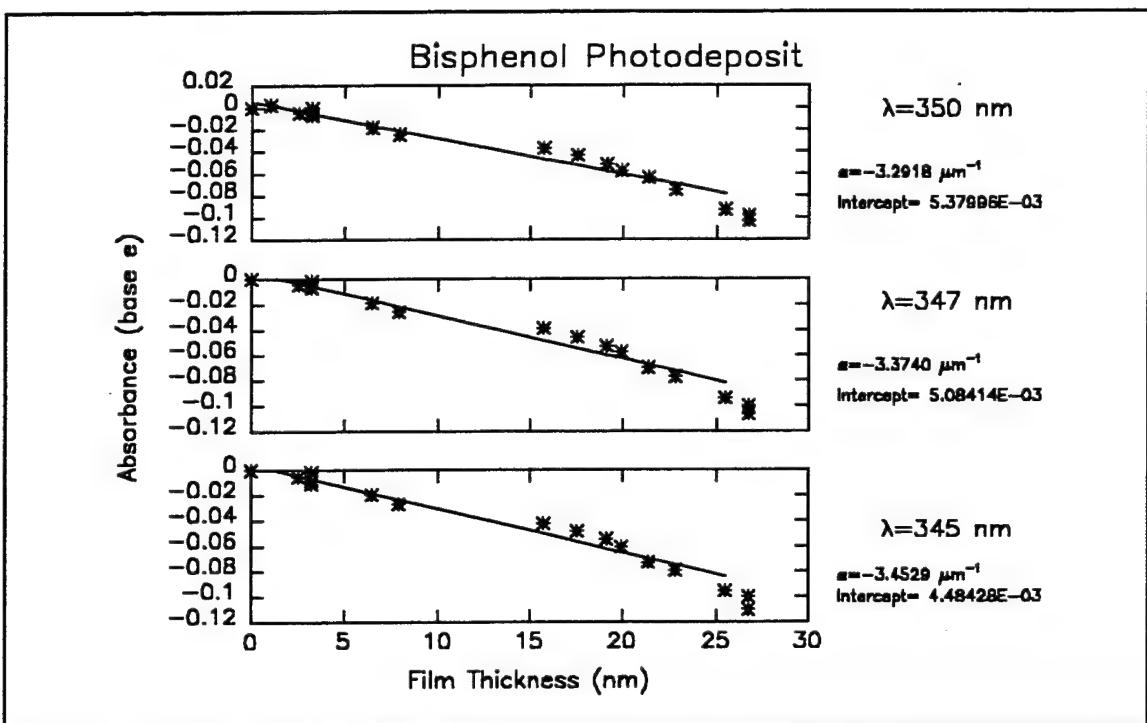


Figure A13g Fits of measured transmission to the Beer-Lambert absorption law. (ultraviolet wavelength range)

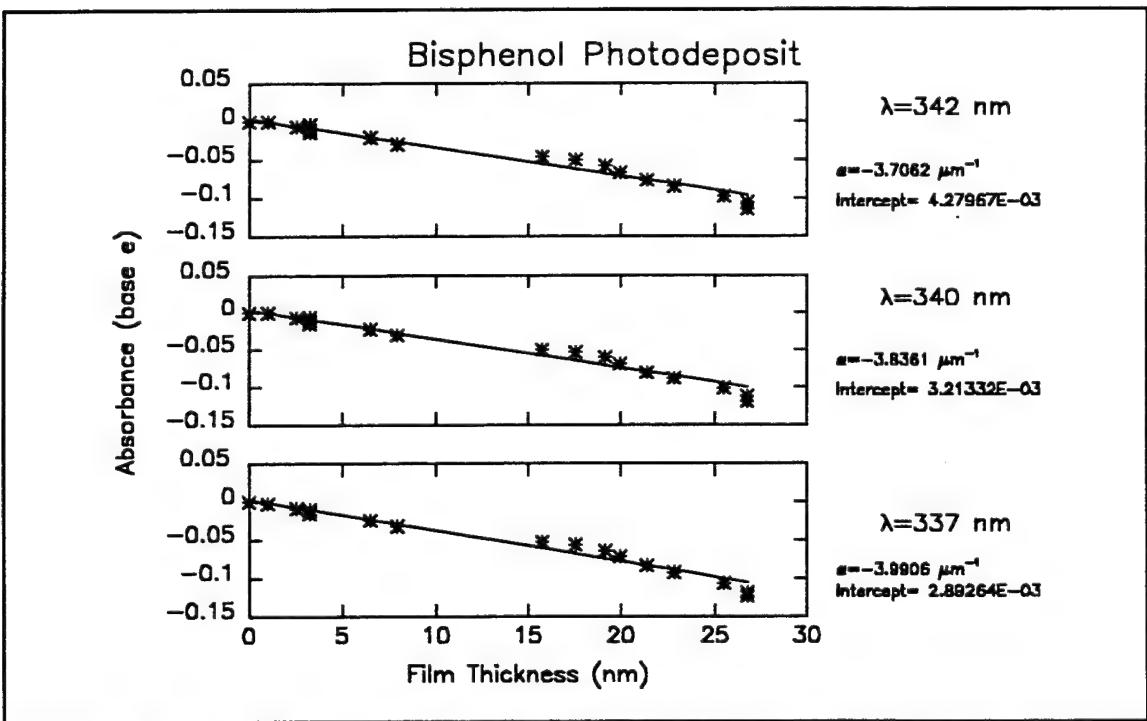


Figure A13h Fits of measured transmission to the Beer-Lambert absorption law. (ultraviolet wavelength range)

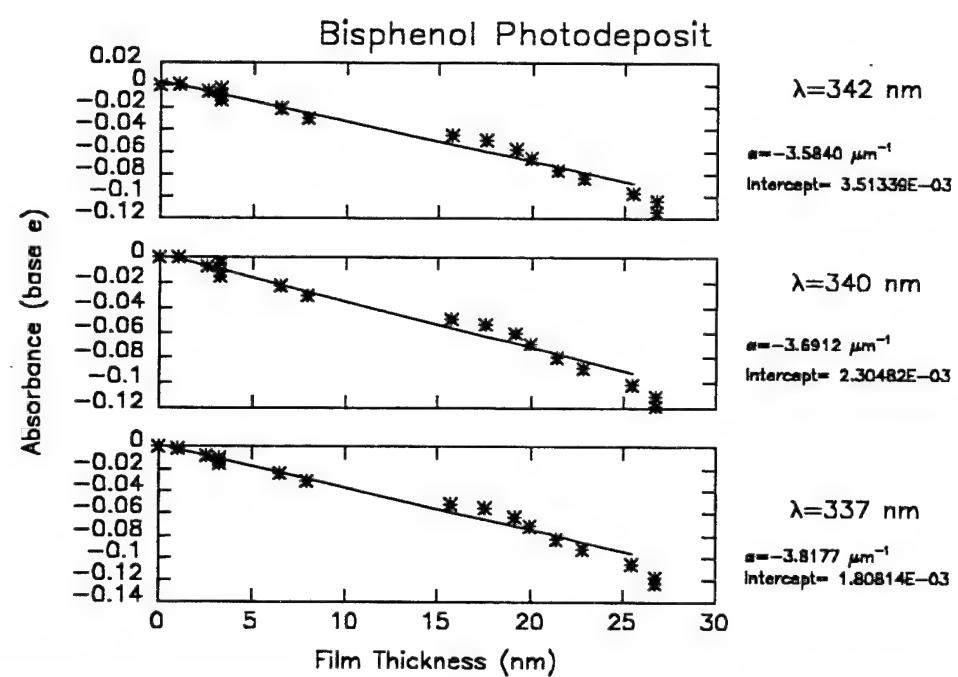


Figure A13i Fits of measured transmission to the Beer-Lambert absorption law. (ultraviolet wavelength range)

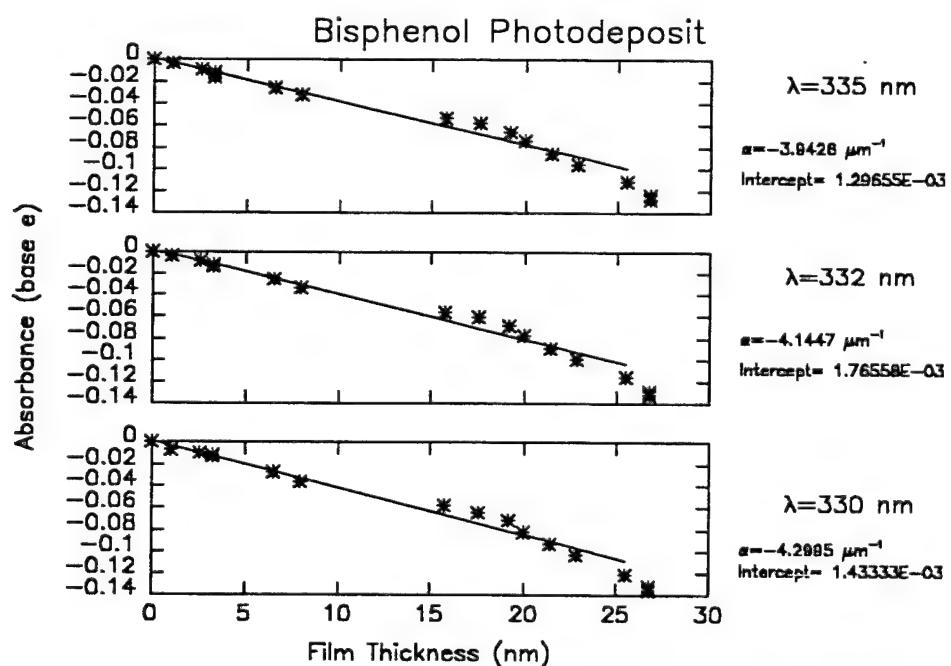


Figure A13j Fits of measured transmission to the Beer-Lambert absorption law. (ultraviolet wavelength range)

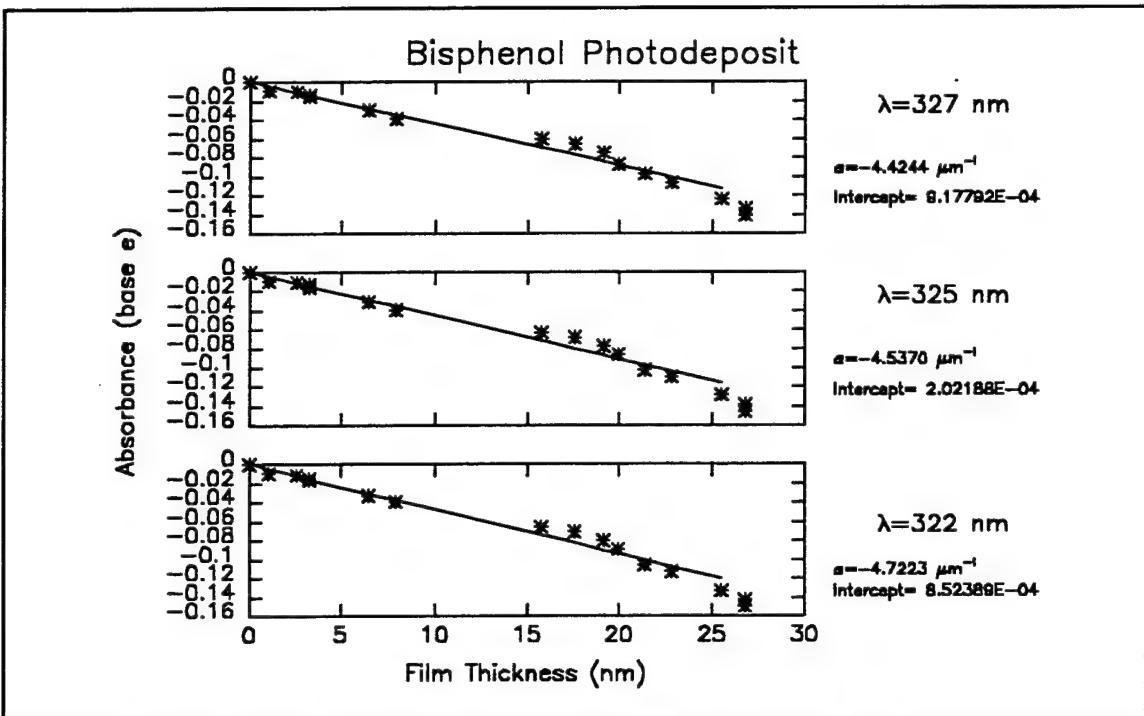


Figure A13k Fits of measured transmission to the Beer-Lambert absorption law. (ultraviolet wavelength range)

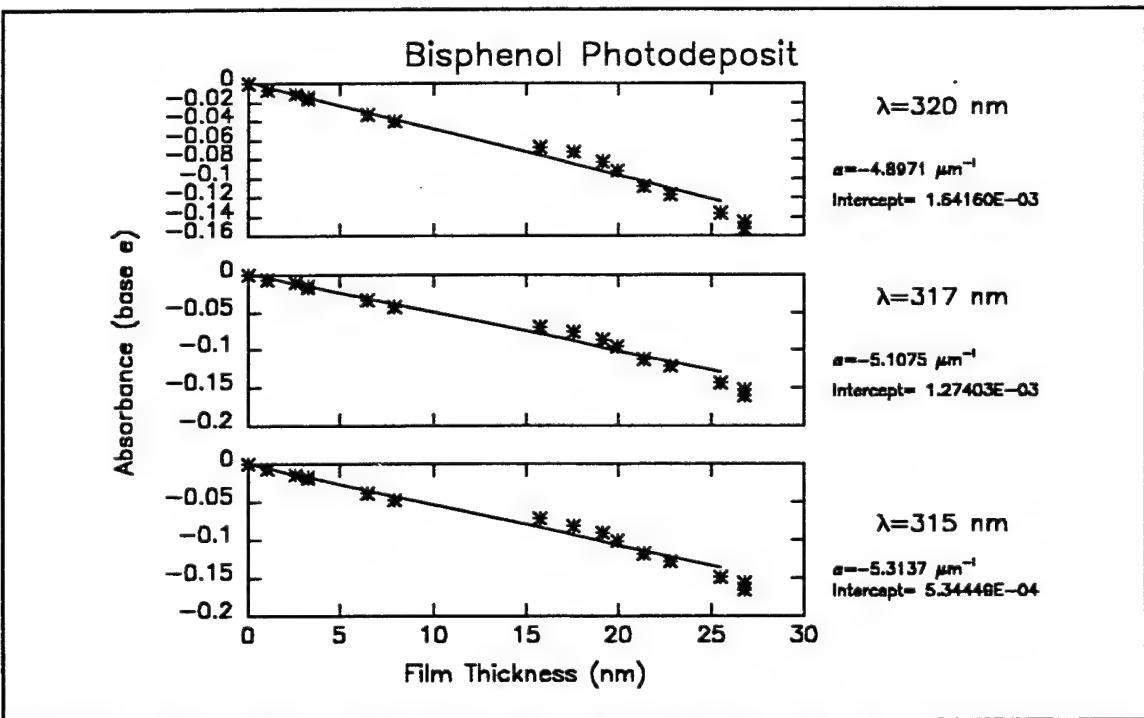


Figure A13l Fits of measured transmission to the Beer-Lambert absorption law. (ultraviolet wavelength range)

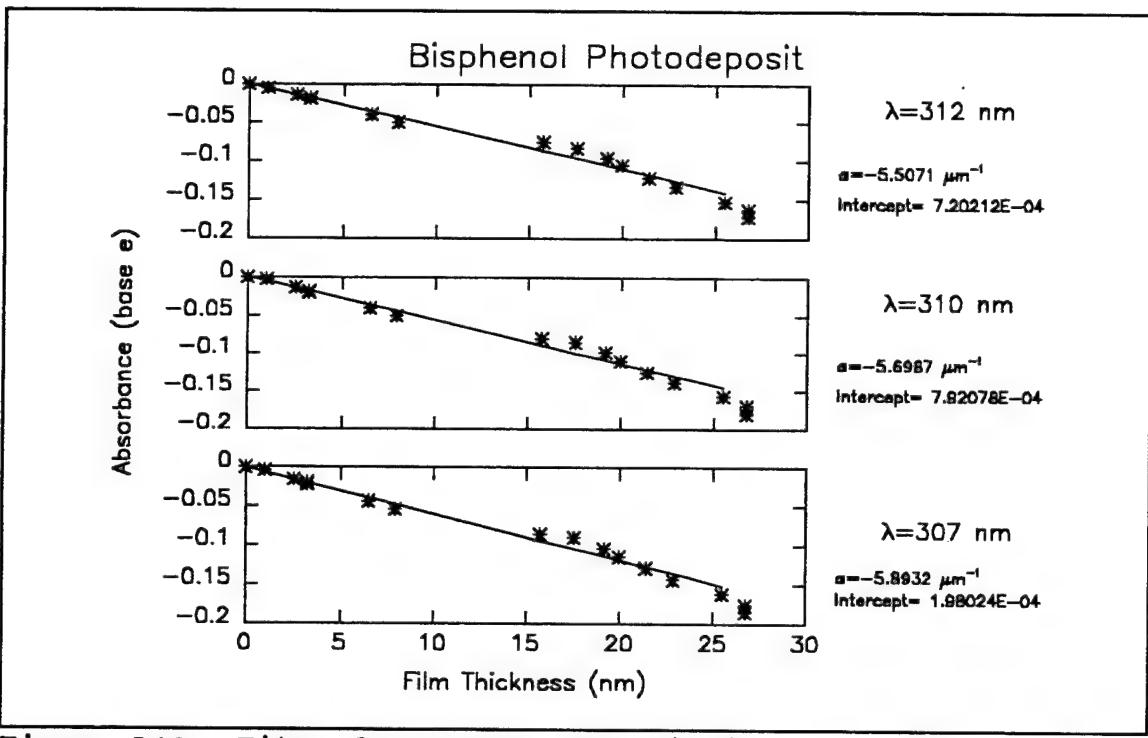


Figure A13m Fits of measured transmission to the Beer-Lambert absorption law. (ultraviolet wavelength range)

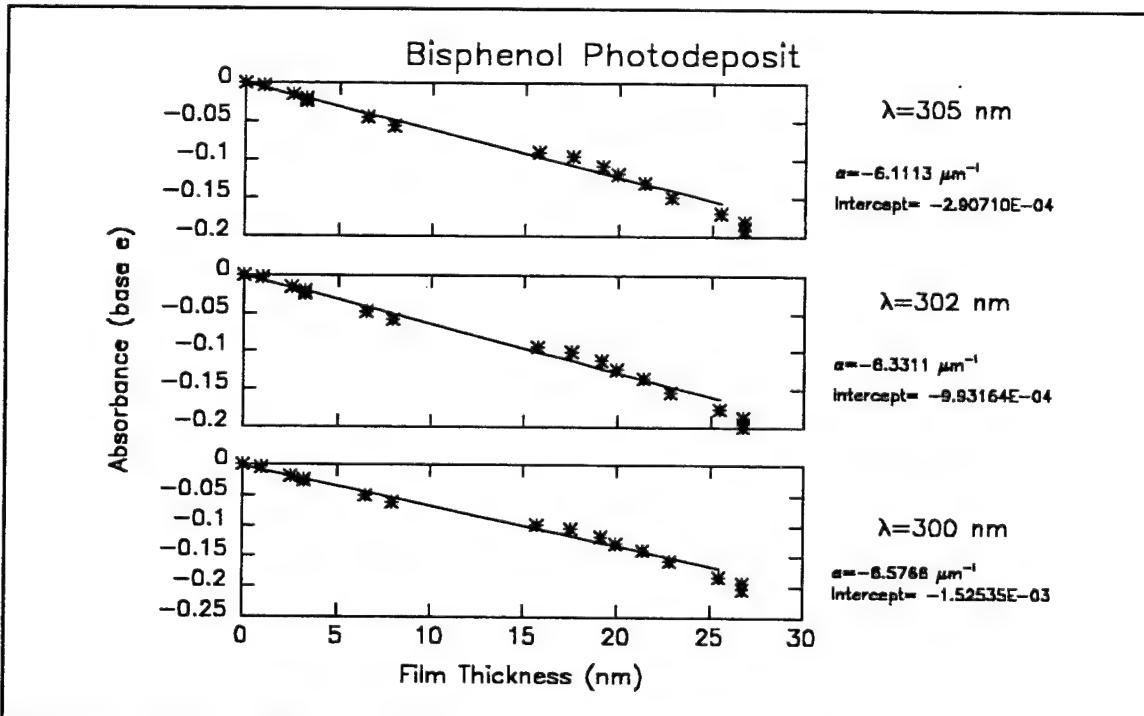


Figure A13n Fits of measured transmission to the Beer-Lambert absorption law. (ultraviolet wavelength range)

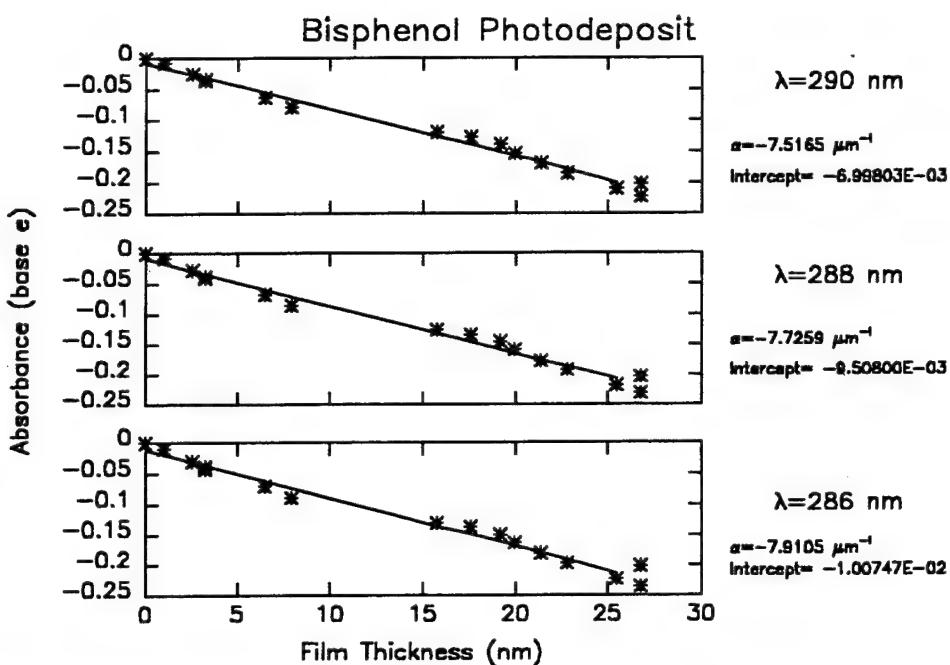


Figure A13o Fits of measured transmission to the Beer-Lambert absorption law. (ultraviolet wavelength range)

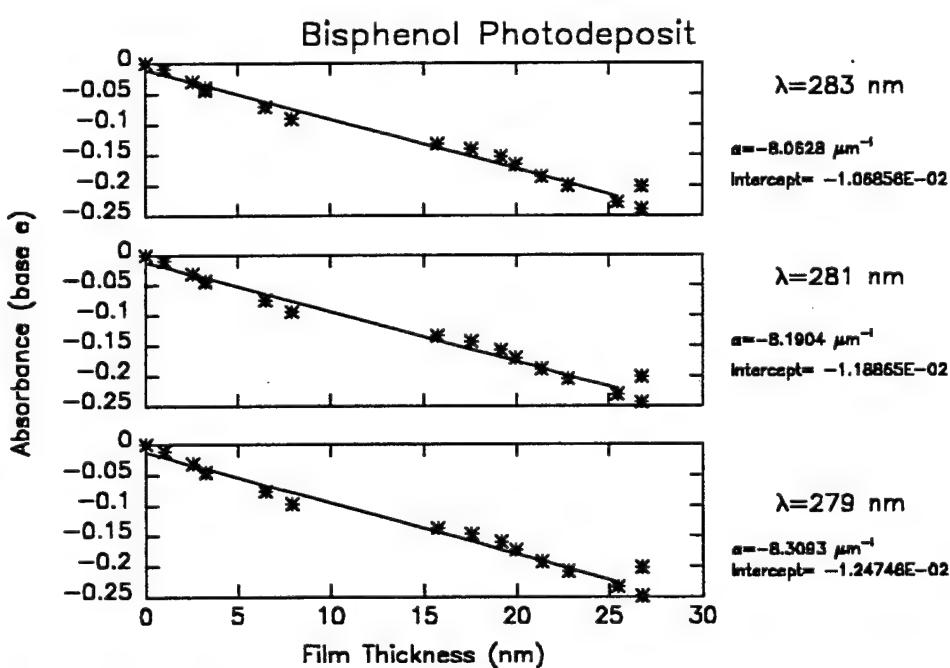


Figure A13p Fits of measured transmission to the Beer-Lambert absorption law. (ultraviolet wavelength range)

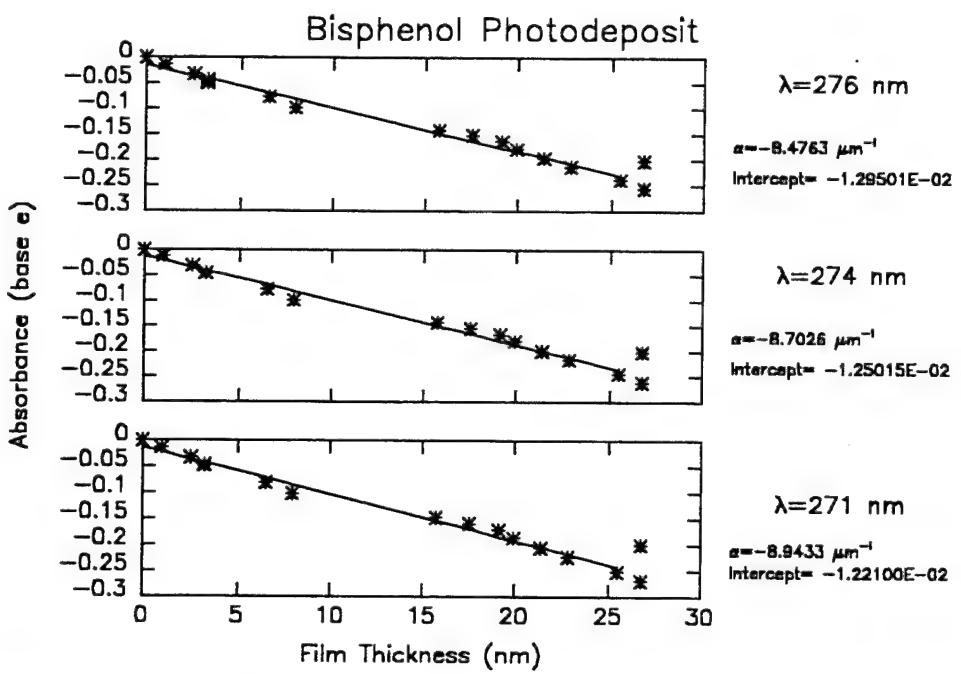


Figure A13q Fits of measured transmission to the Beer-Lambert absorption law. (ultraviolet wavelength range)

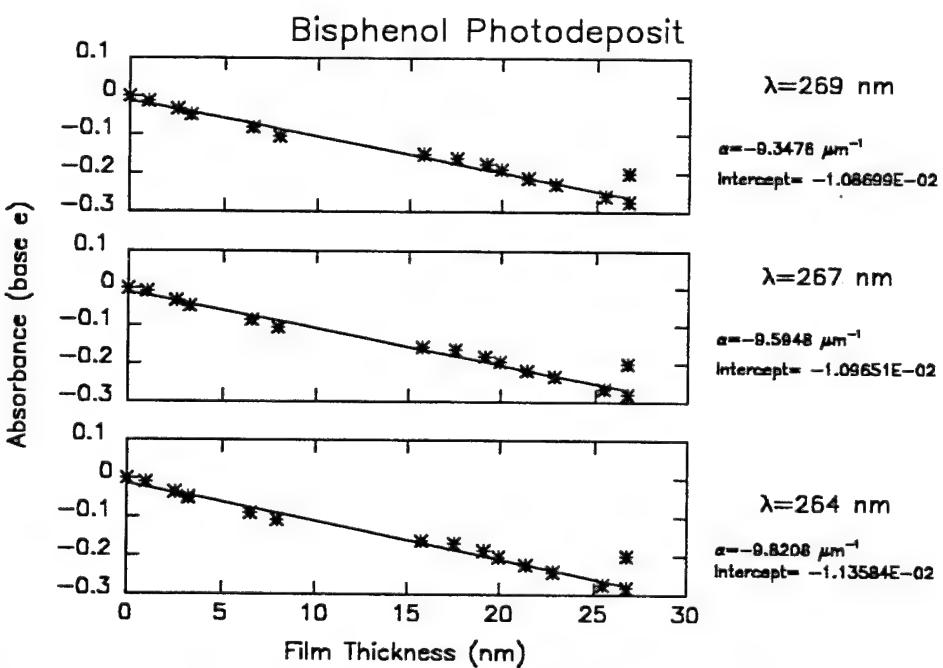


Figure A13r Fits of measured transmission to the Beer-Lambert absorption law. (ultraviolet wavelength range)

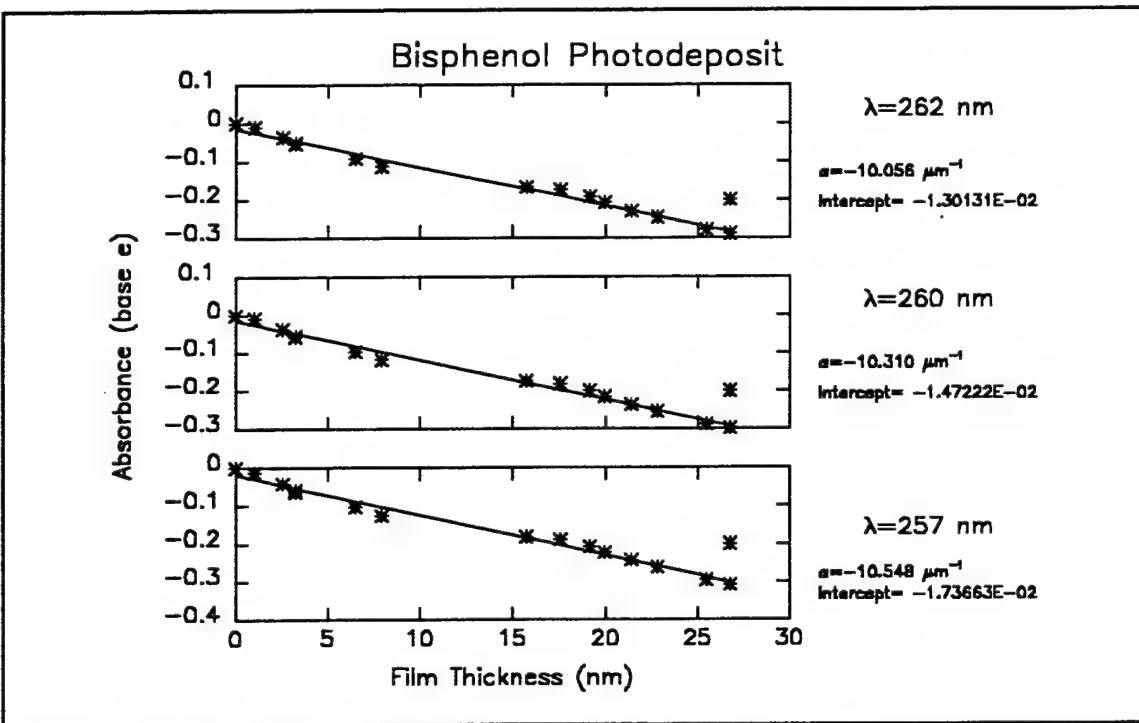


Figure A13s Fits of measured transmission to the Beer-Lambert absorption law. (ultraviolet wavelength range)

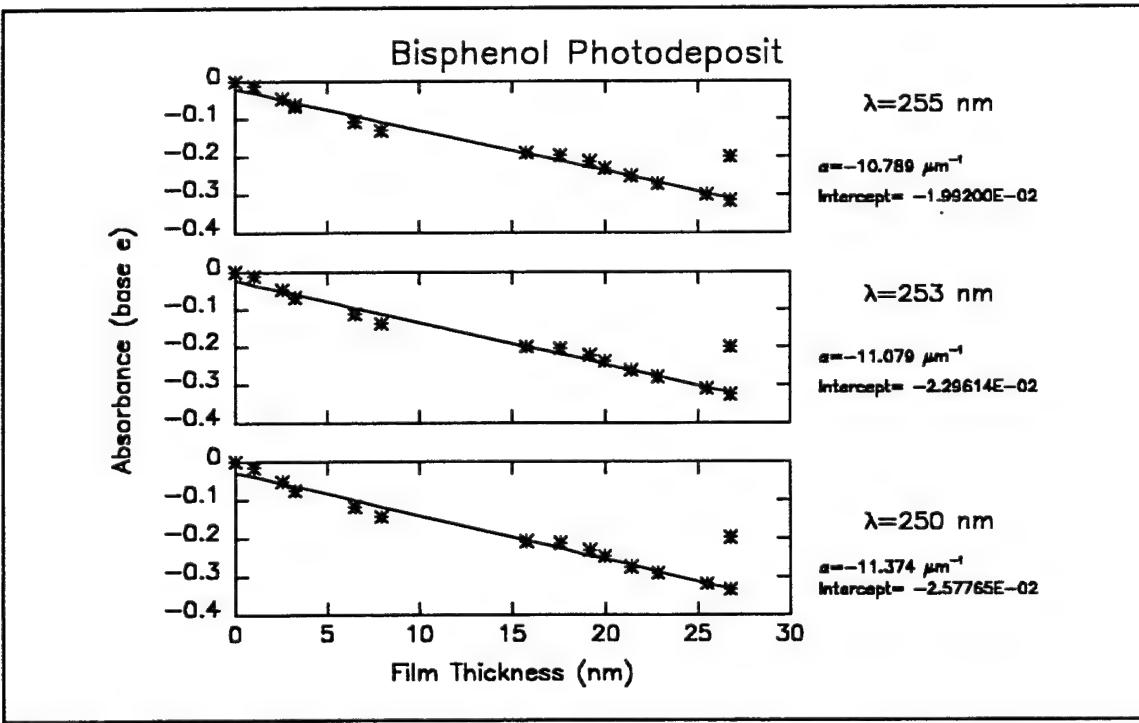


Figure A13t Fits of measured transmission to the Beer-Lambert absorption law. (ultraviolet wavelength range)

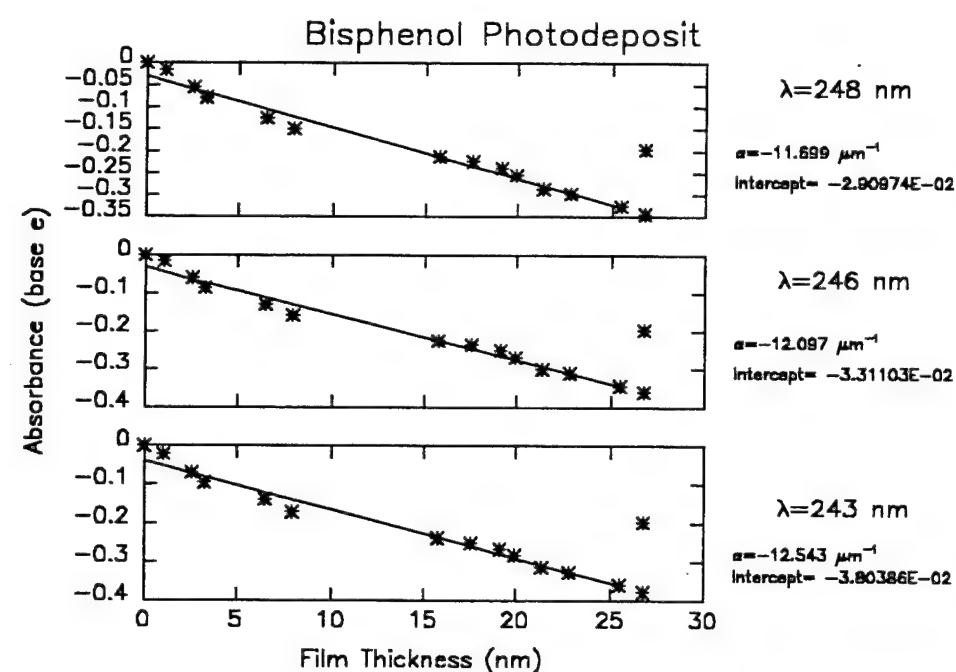


Figure A13u Fits of measured transmission to the Beer-Lambert absorption law. (ultraviolet wavelength range)

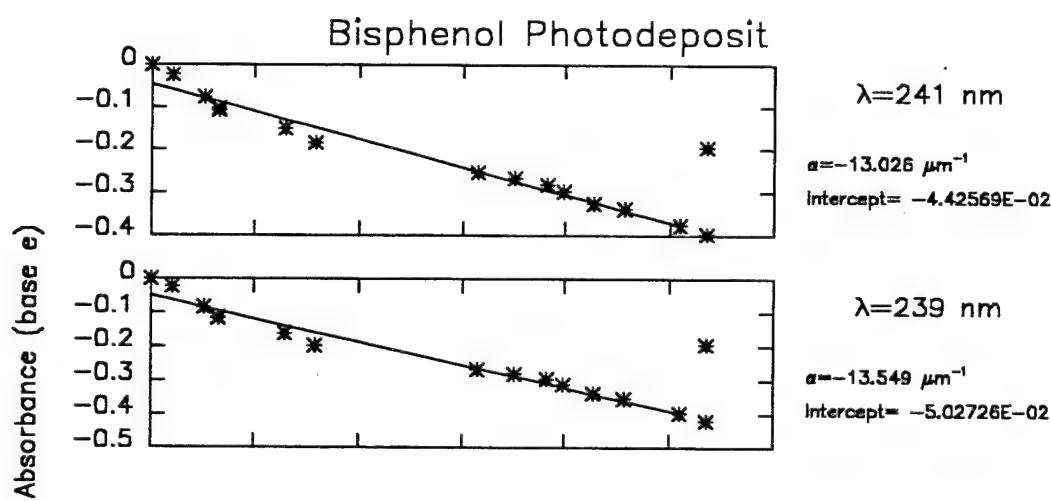


Figure A13v Fits of measured transmission to the Beer-Lambert absorption law. (ultraviolet wavelength range)

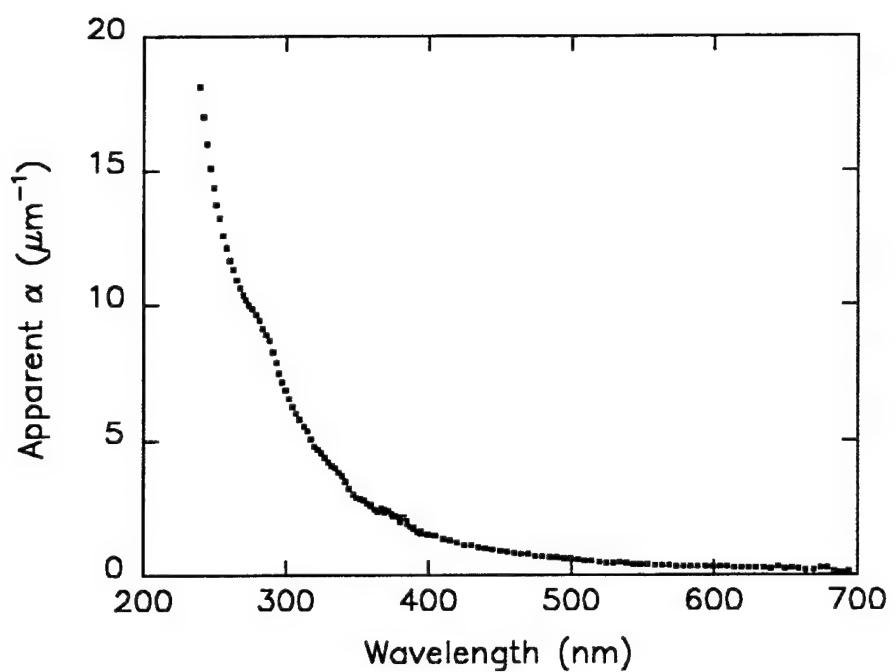


Figure A14. Apparent absorption coefficient obtained from the constrained data fits. Linear plot

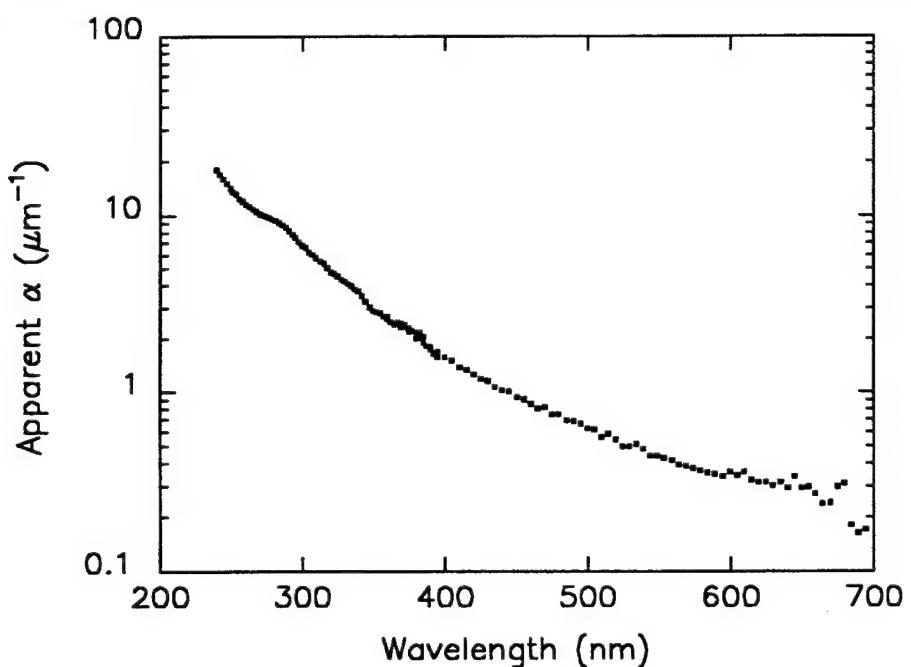


Figure A15. Apparent absorption coefficient obtained from the constrained data fits. Log plot

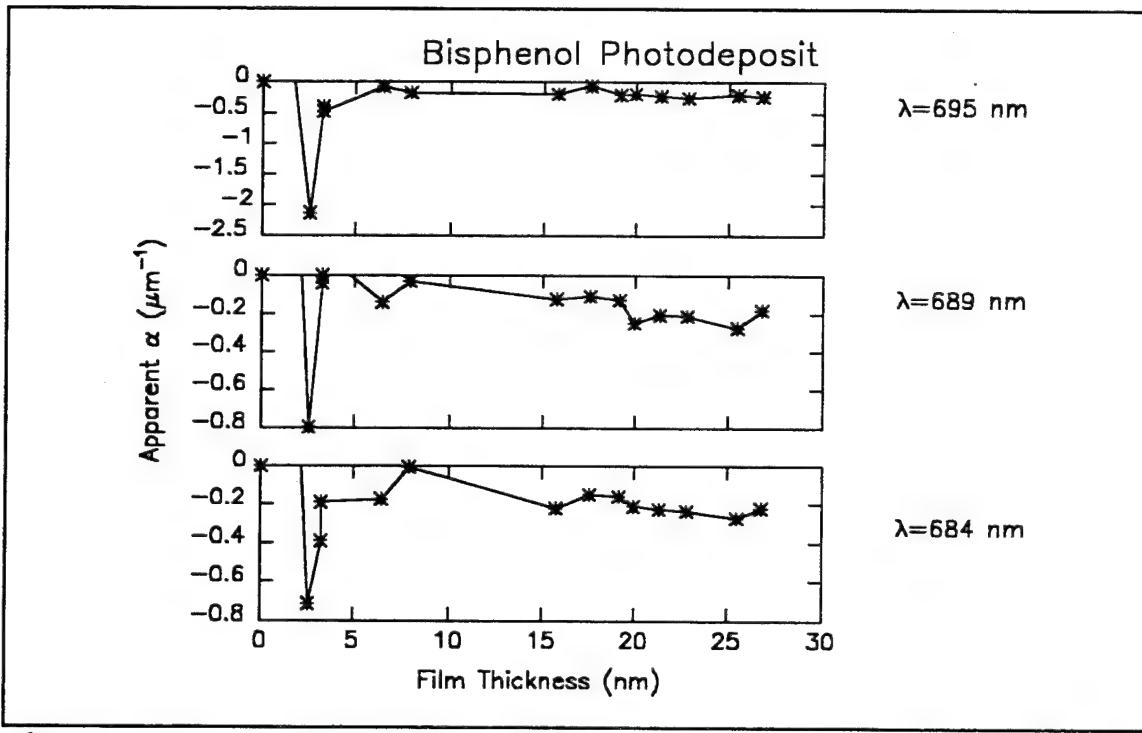


Figure A16a Computed values of α_j for the Bisphenol photodeposit, visible range.

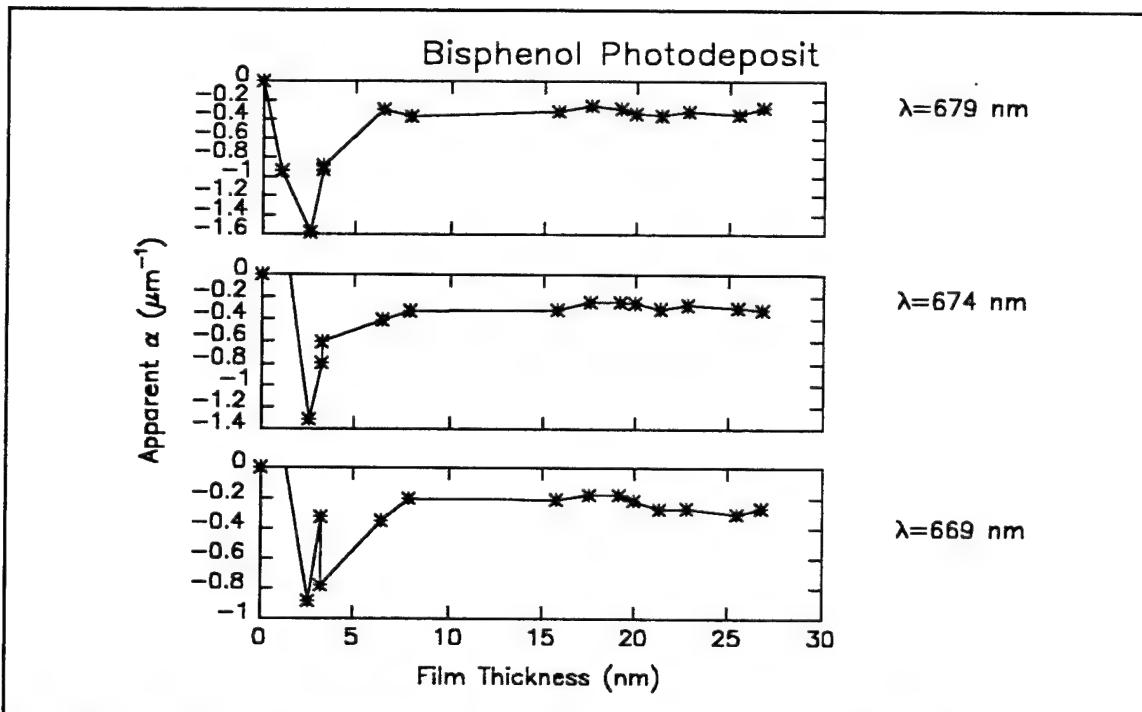


Figure A16b Computed values of α_j for the Bisphenol photodeposit, visible range.

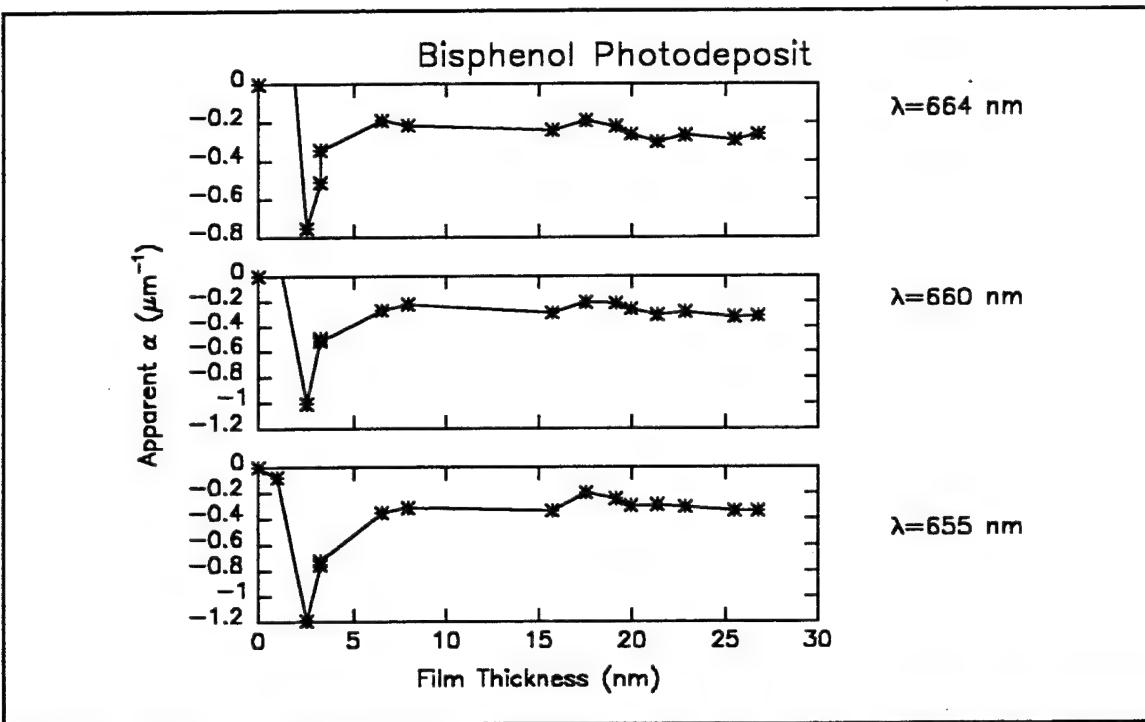


Figure A16c Computed values of α_j for the Bisphenol photodeposit, visible range.

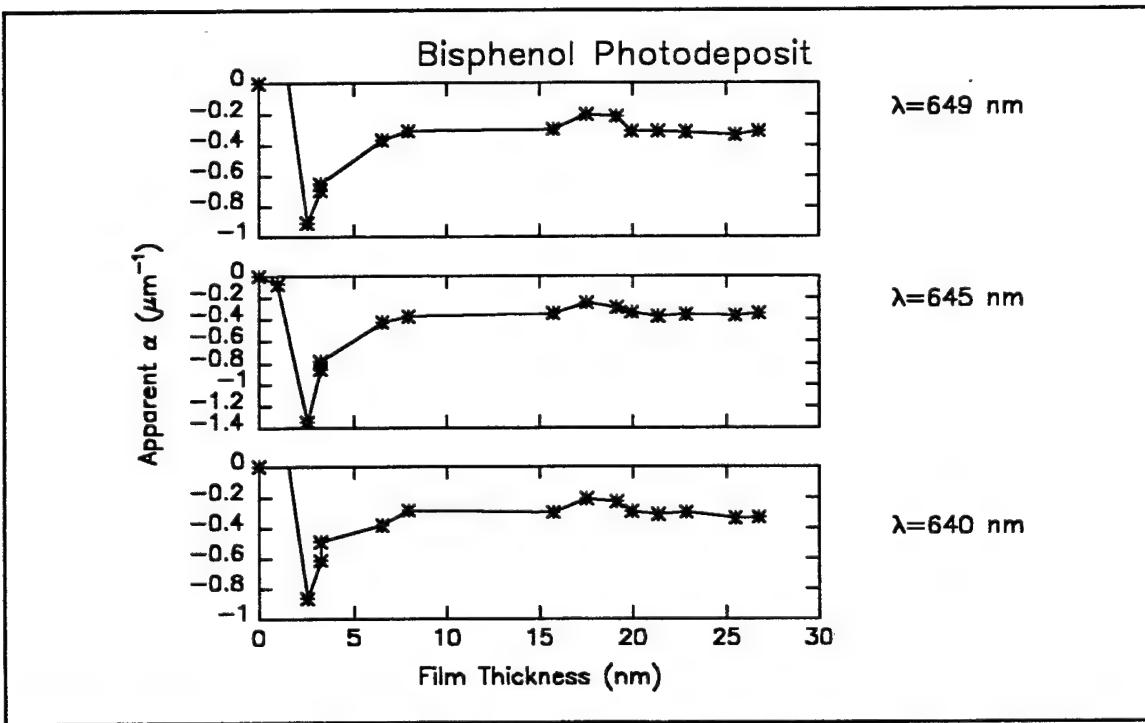


Figure A16d Computed values of α_j for the Bisphenol photodeposit, visible range.

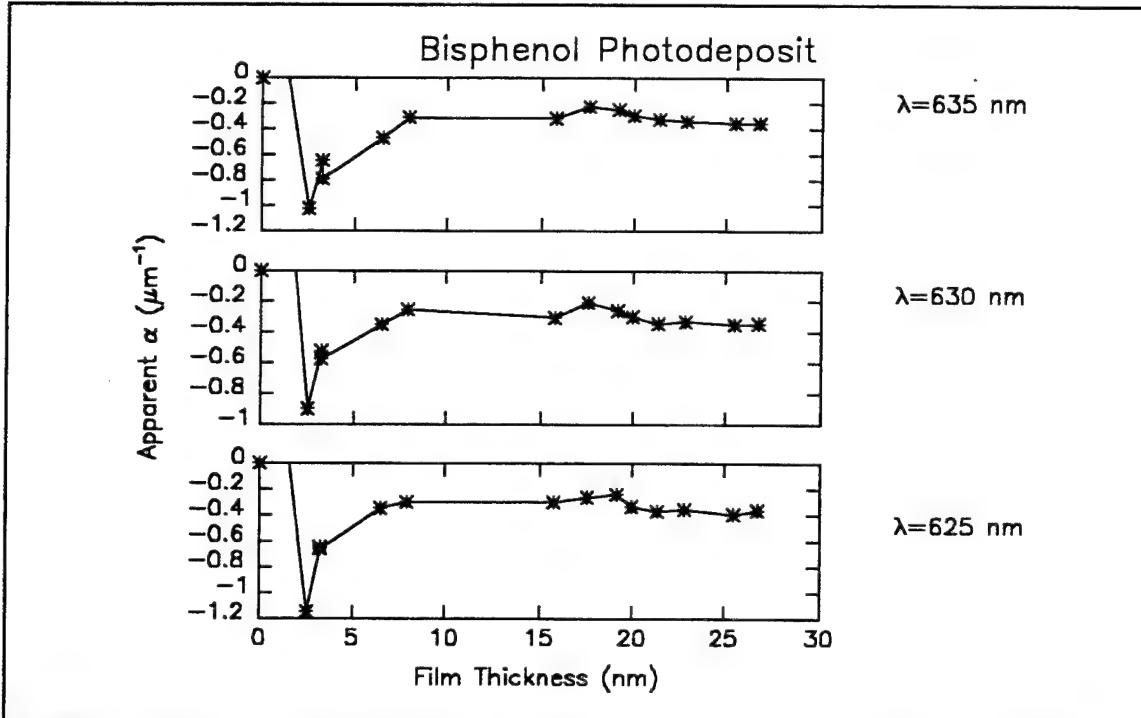


Figure A16e Computed values of α_j for the Bisphenol photodeposit, visible range.

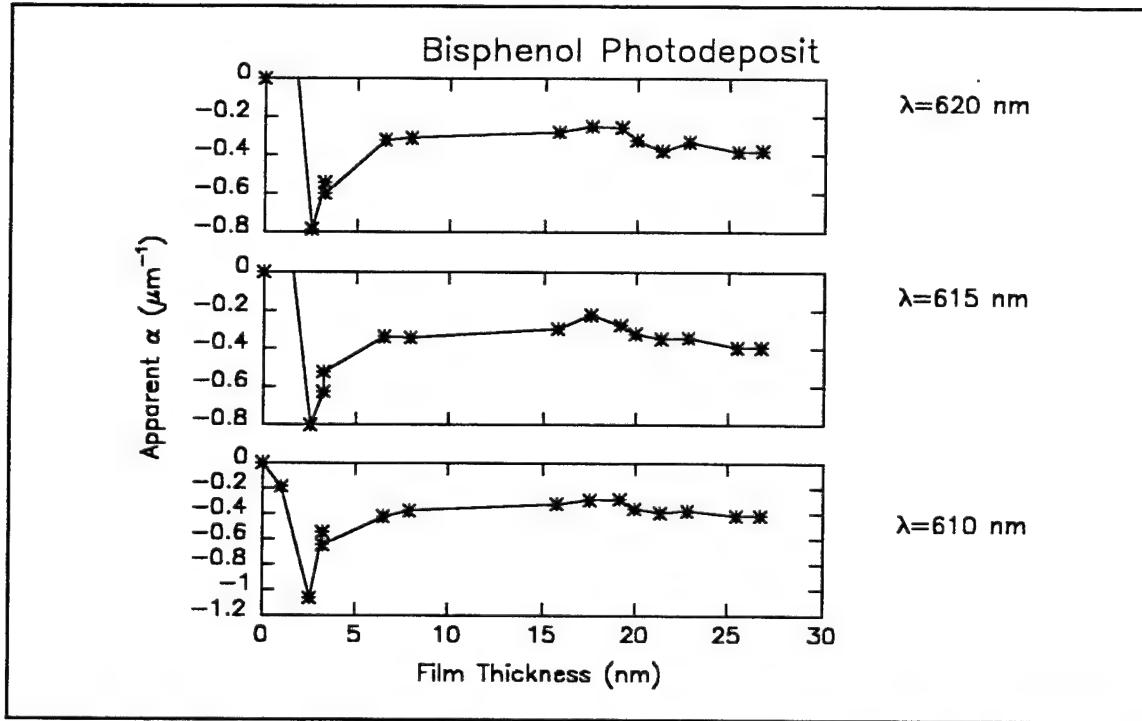


Figure A16f Computed values of α_j for the Bisphenol photodeposit, visible range.

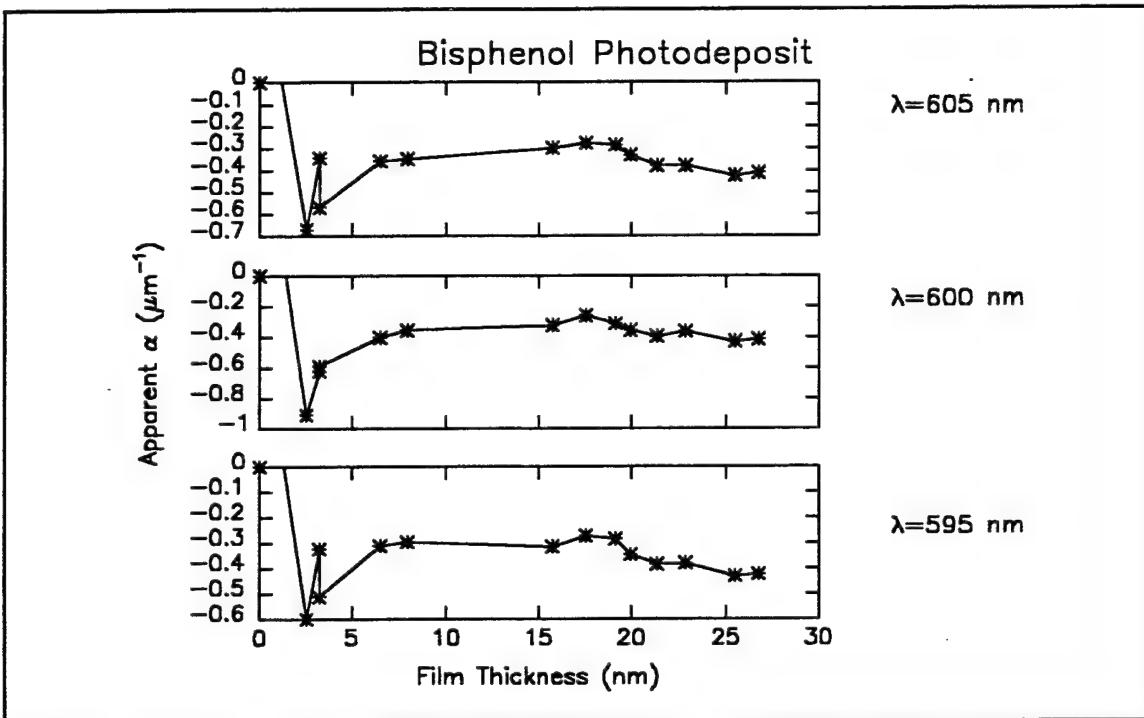


Figure A16g Computed values of α_j for the Bisphenol photodeposit, visible range.

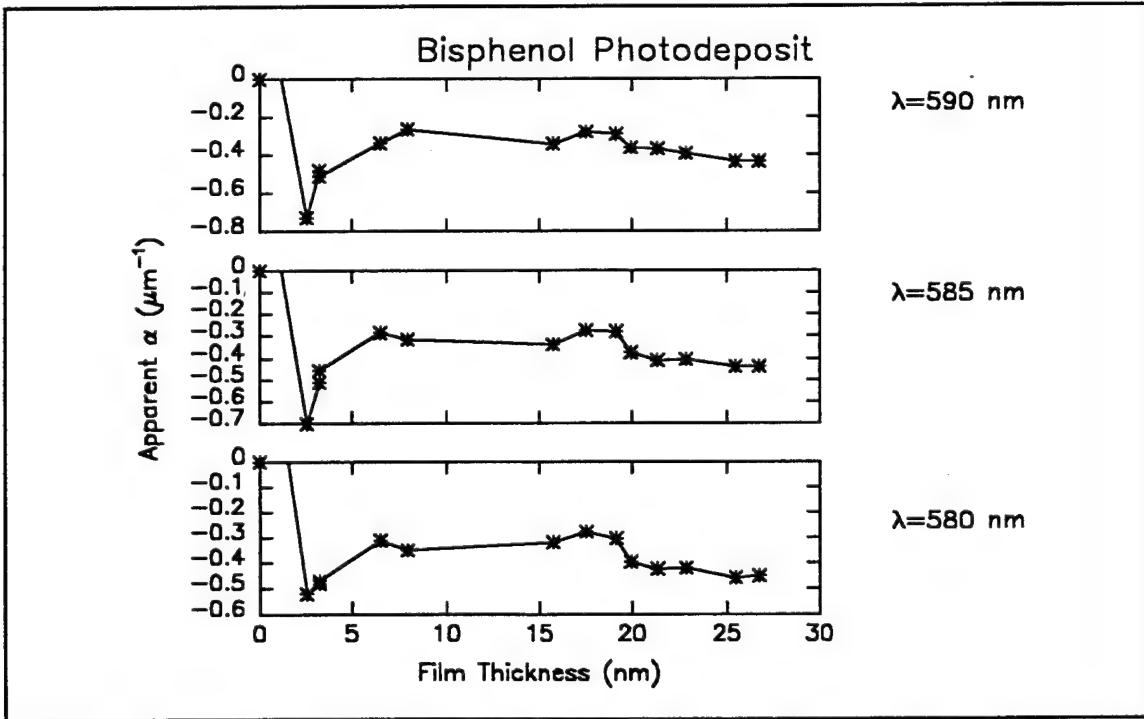


Figure A16h Computed values of α_j for the Bisphenol photodeposit, visible range.

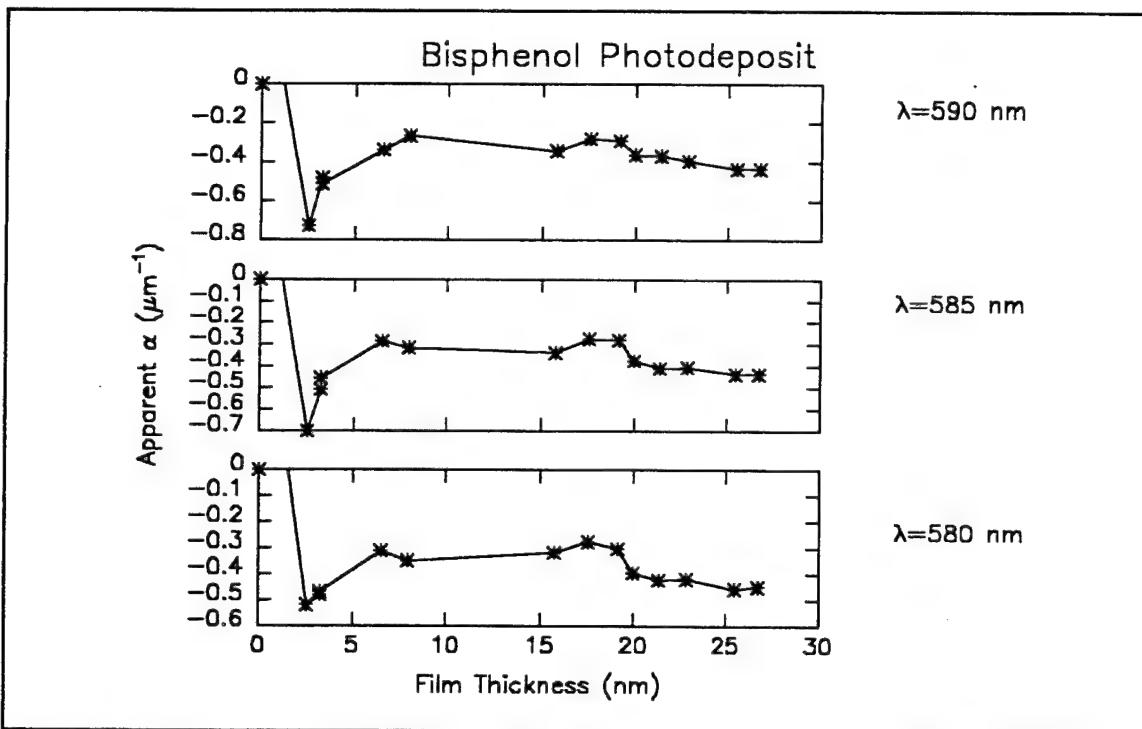


Figure A16i Computed values of α_j for the Bisphenol photodeposit, visible range.

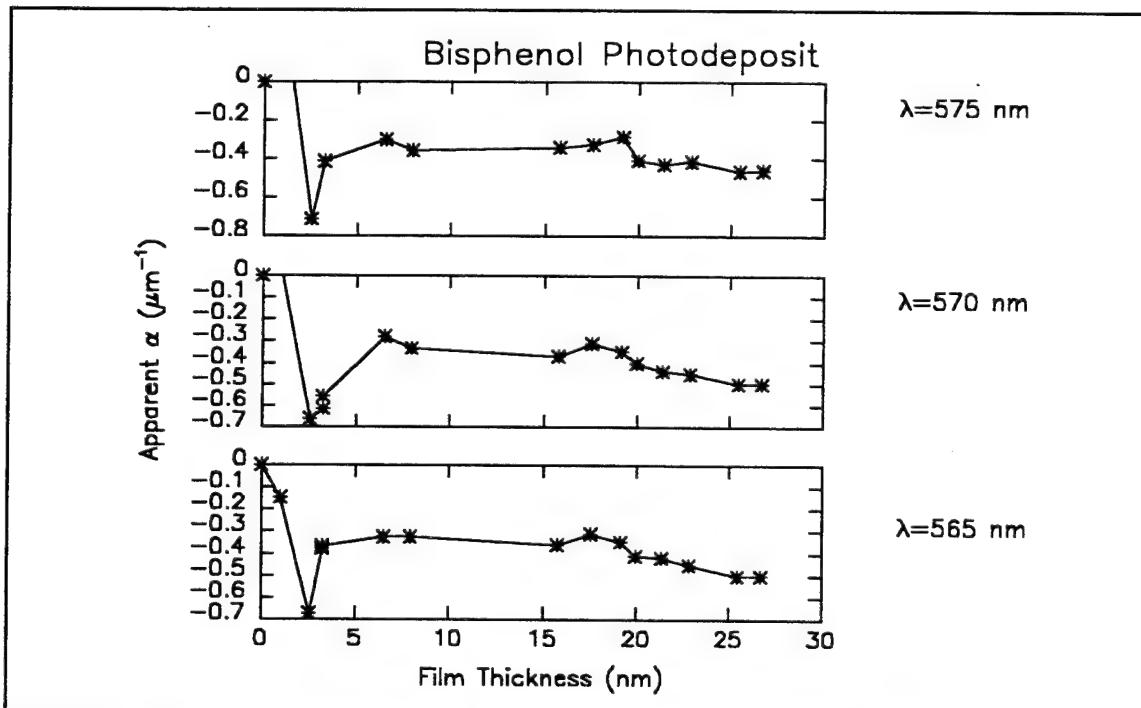


Figure A16j Computed values of α_j for the Bisphenol photodeposit, visible range.

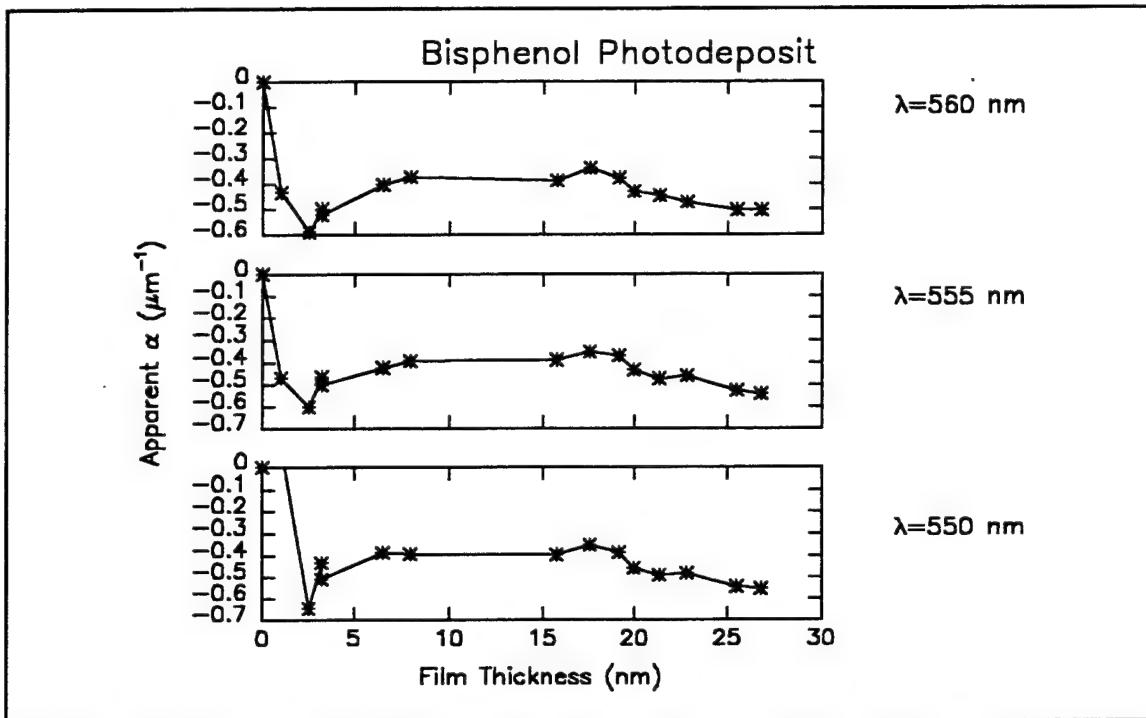


Figure A16k Computed values of α_j for the Bisphenol photodeposit, visible range.

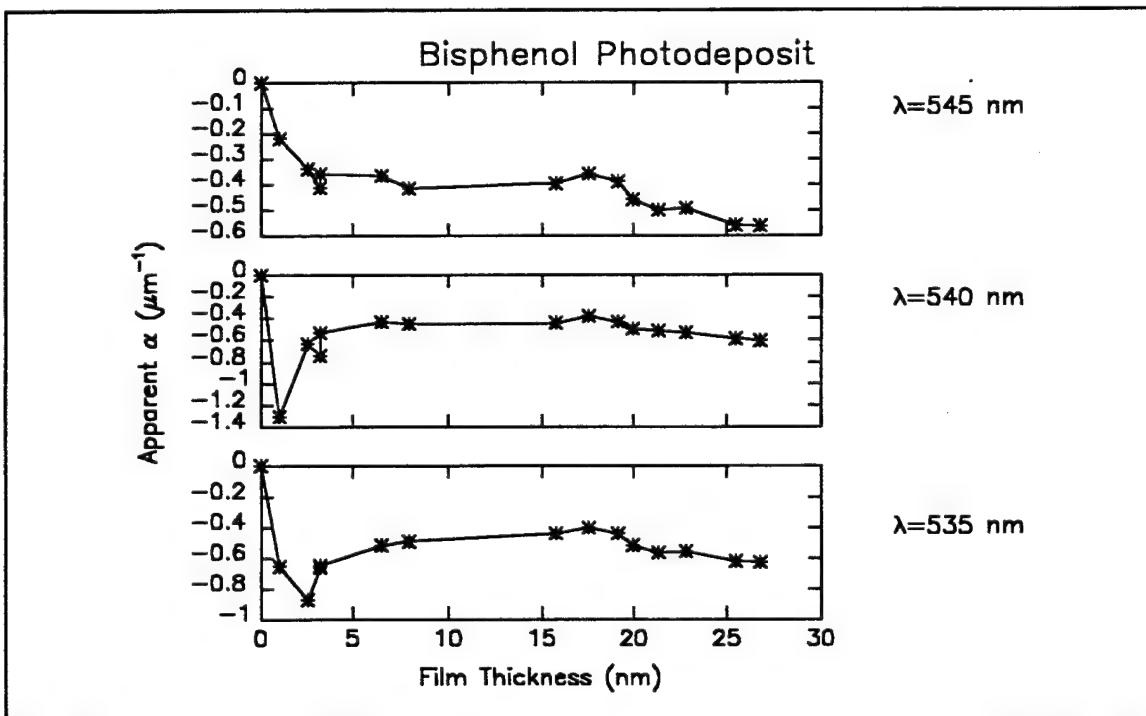


Figure A16l Computed values of α_j for the Bisphenol photodeposit, visible range.

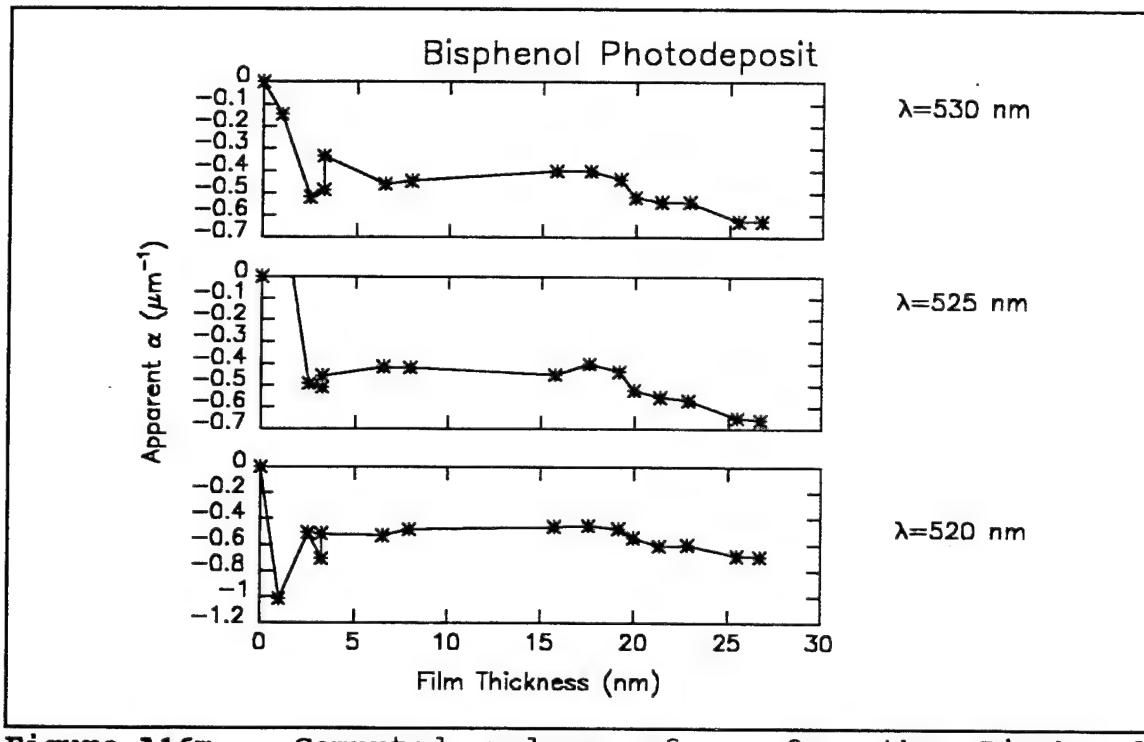


Figure A16m Computed values of α_j for the Bisphenol photodeposit, visible range.

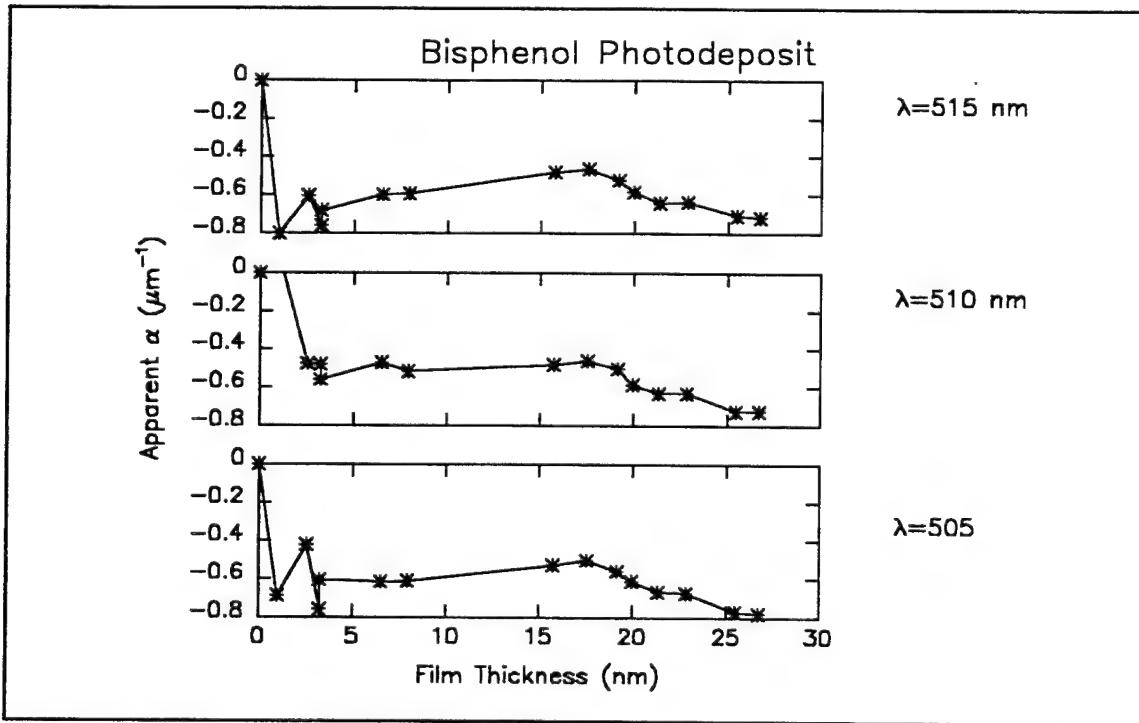


Figure A16n Computed values of α_j for the Bisphenol photodeposit, visible range.

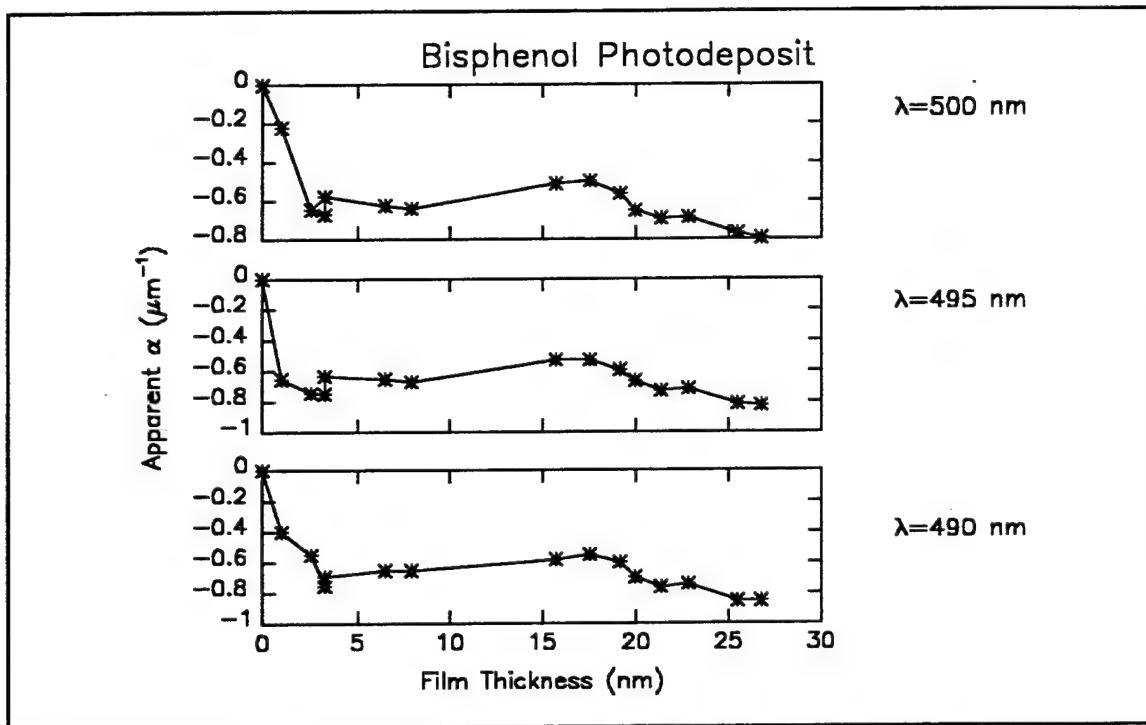


Figure A16o Computed values of α_j for the Bisphenol photodeposit, visible range.

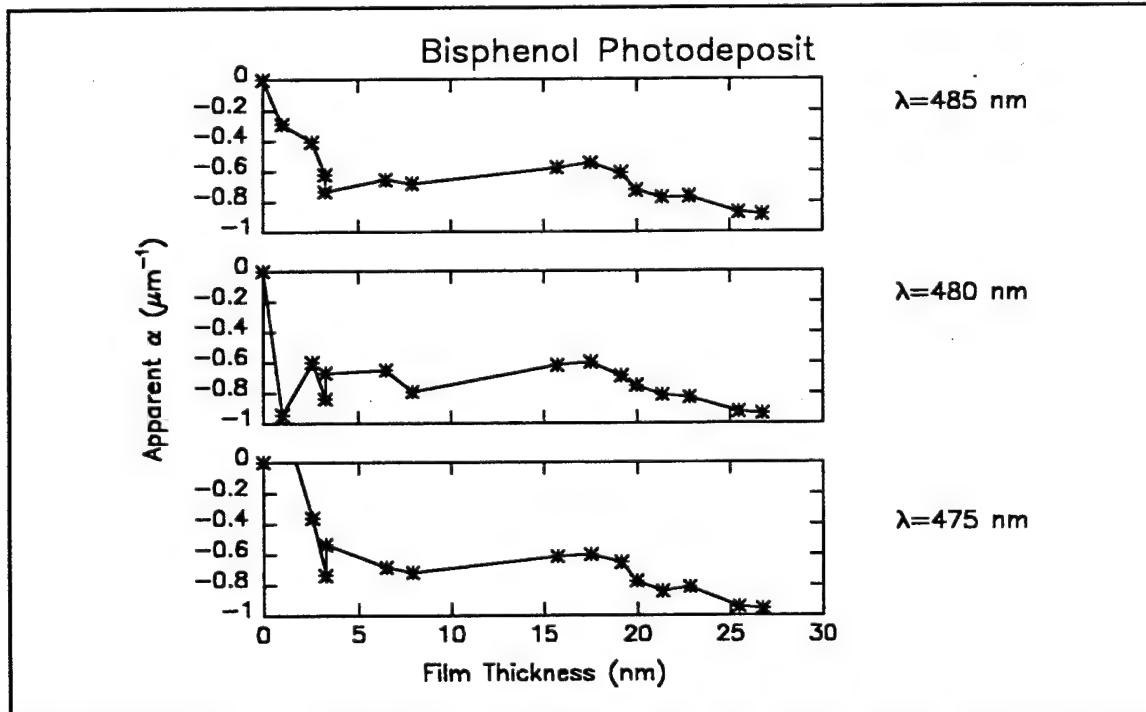


Figure A16p Computed values of α_j for the Bisphenol photodeposit, visible range.

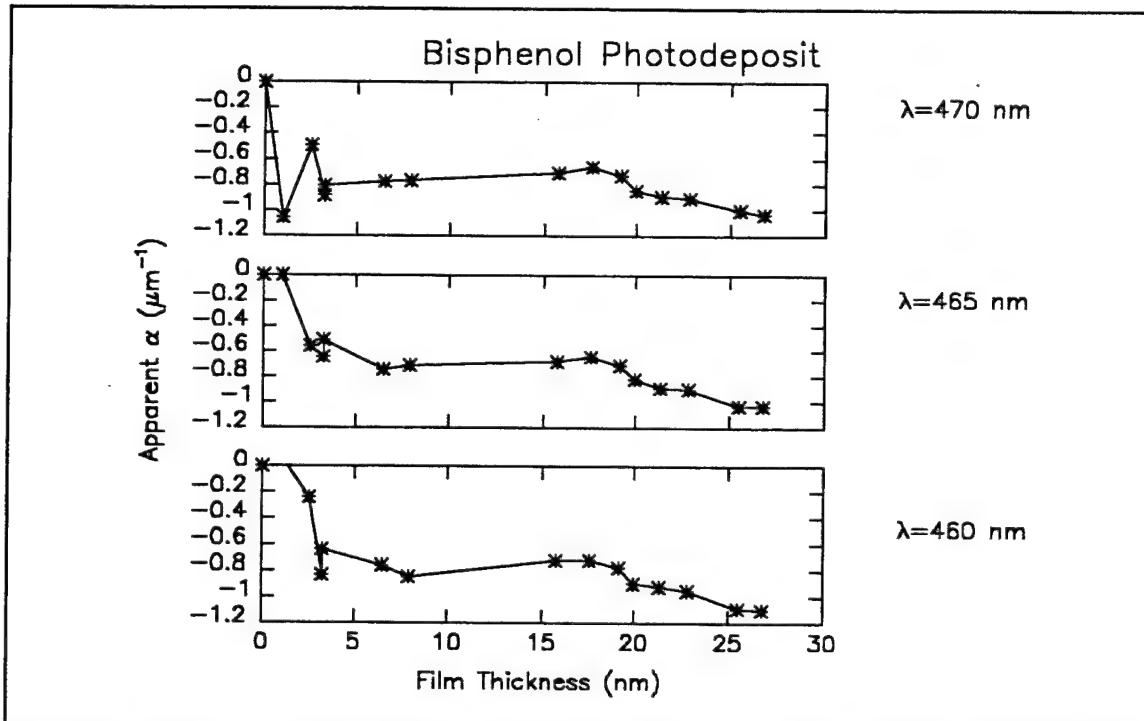


Figure A16q Computed values of α_j for the Bisphenol photodeposit, visible range.

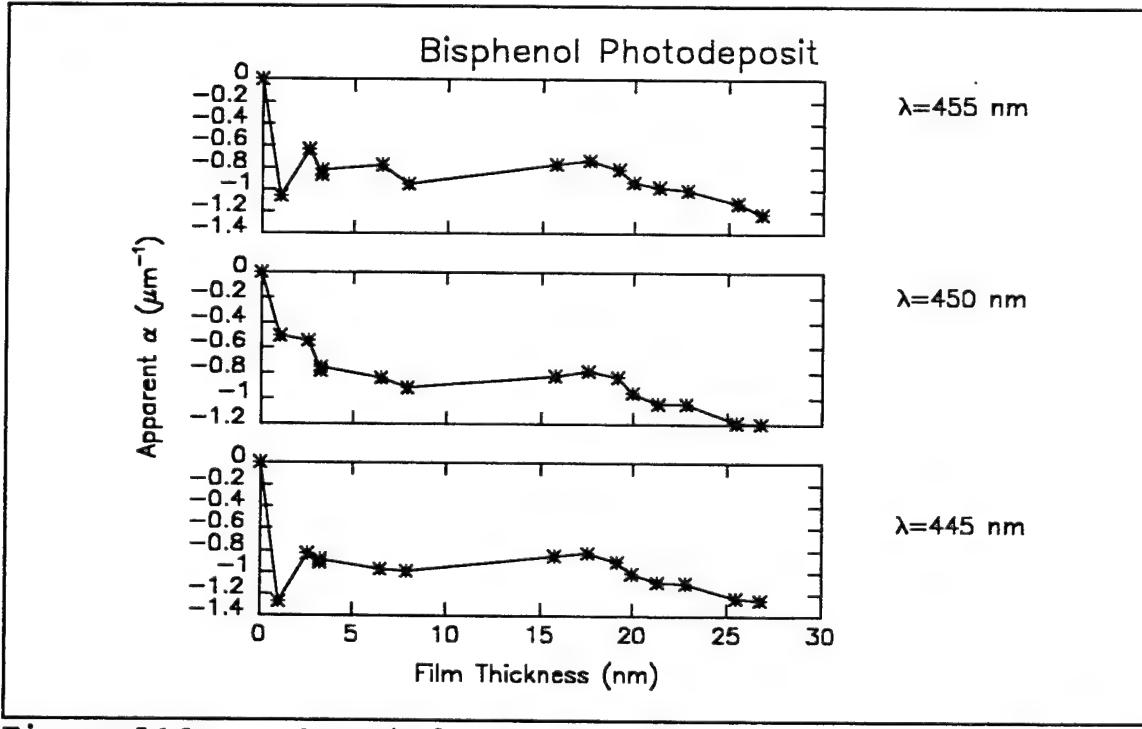


Figure A16r Computed values of α_j for the Bisphenol photodeposit, visible range.

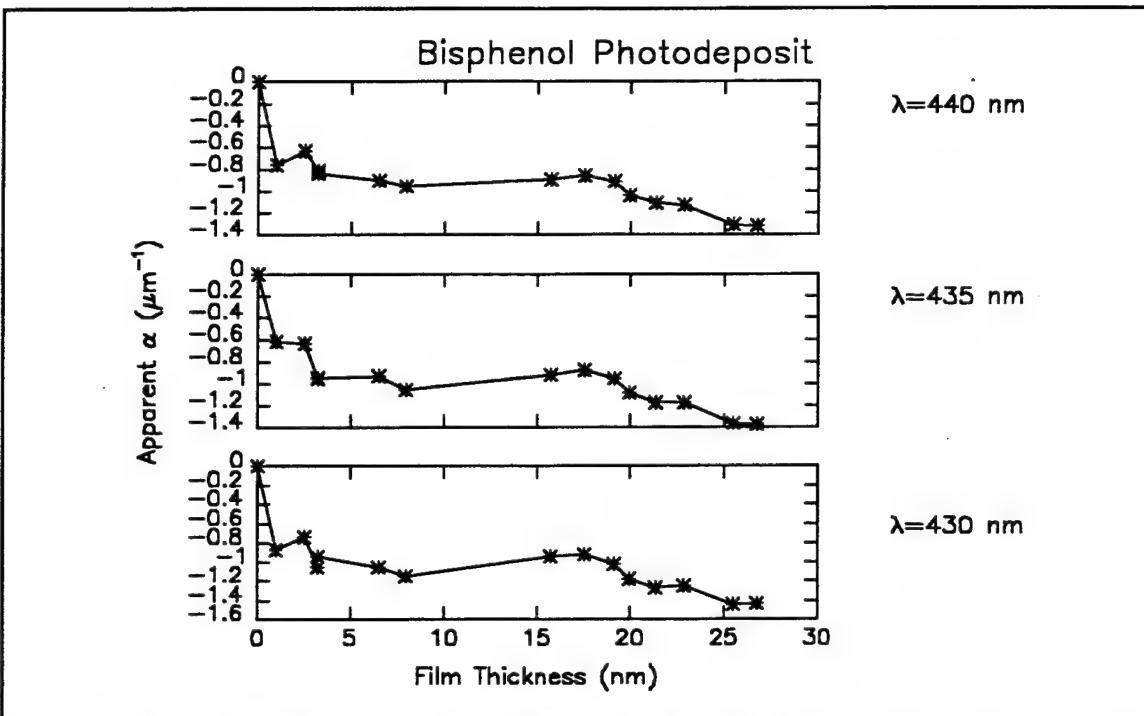


Figure A16s Computed values of α_i for the Bisphenol photodeposit, visible range.

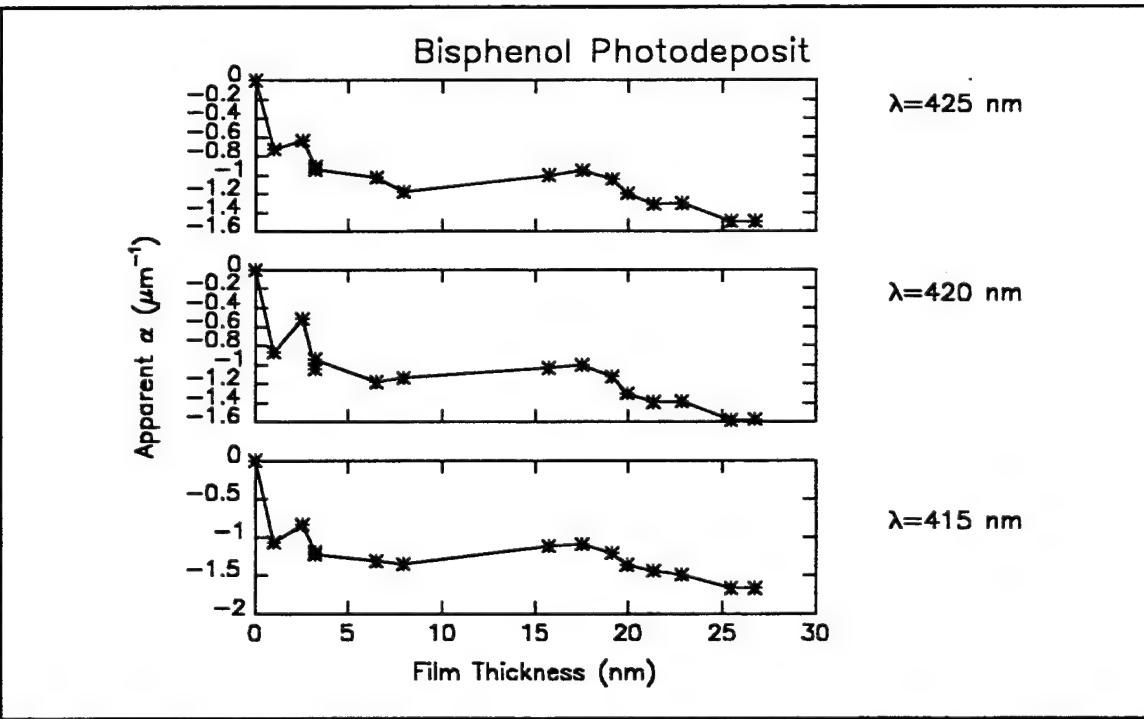


Figure A16t Computed values of α_i for the Bisphenol photodeposit, visible range.

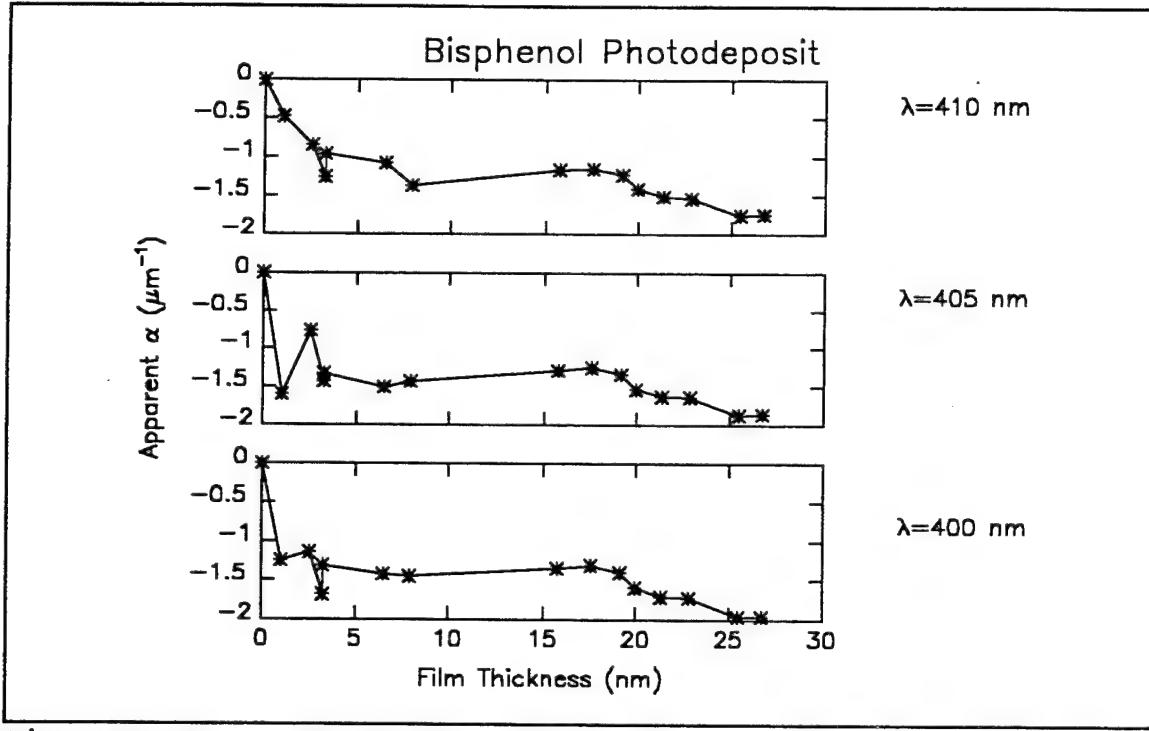


Figure A16u Computed values of α_j for the Bisphenol photodeposit, visible range.

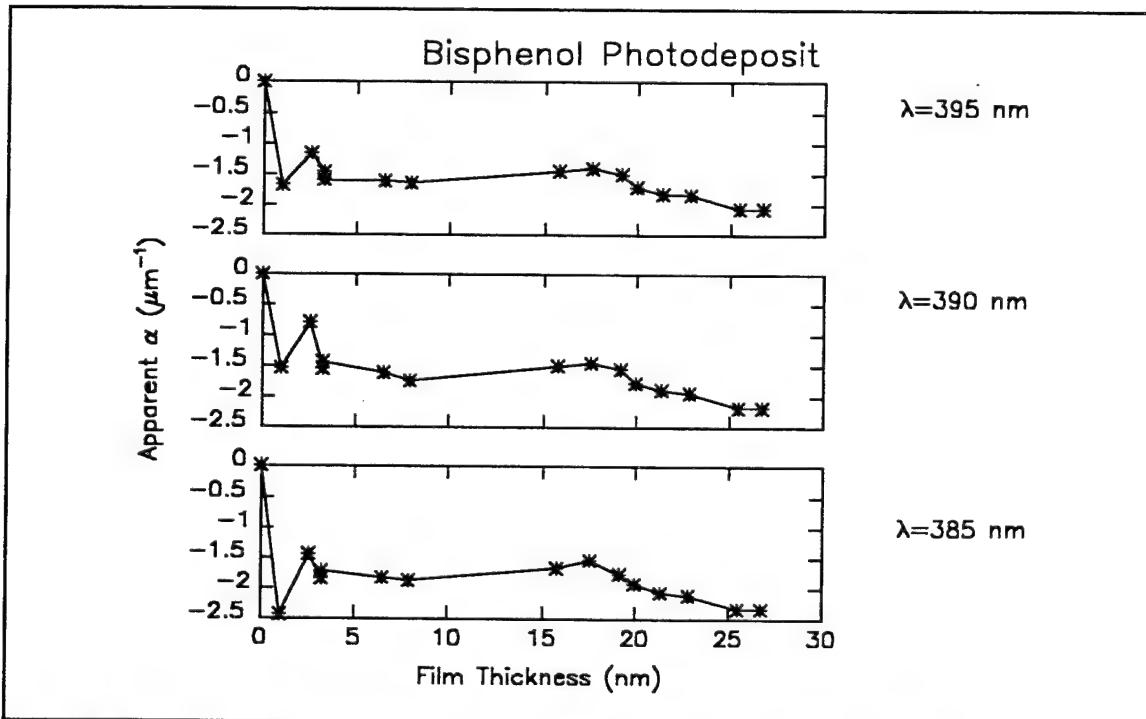


Figure A16v Computed values of α_j for the Bisphenol photodeposit, visible range.

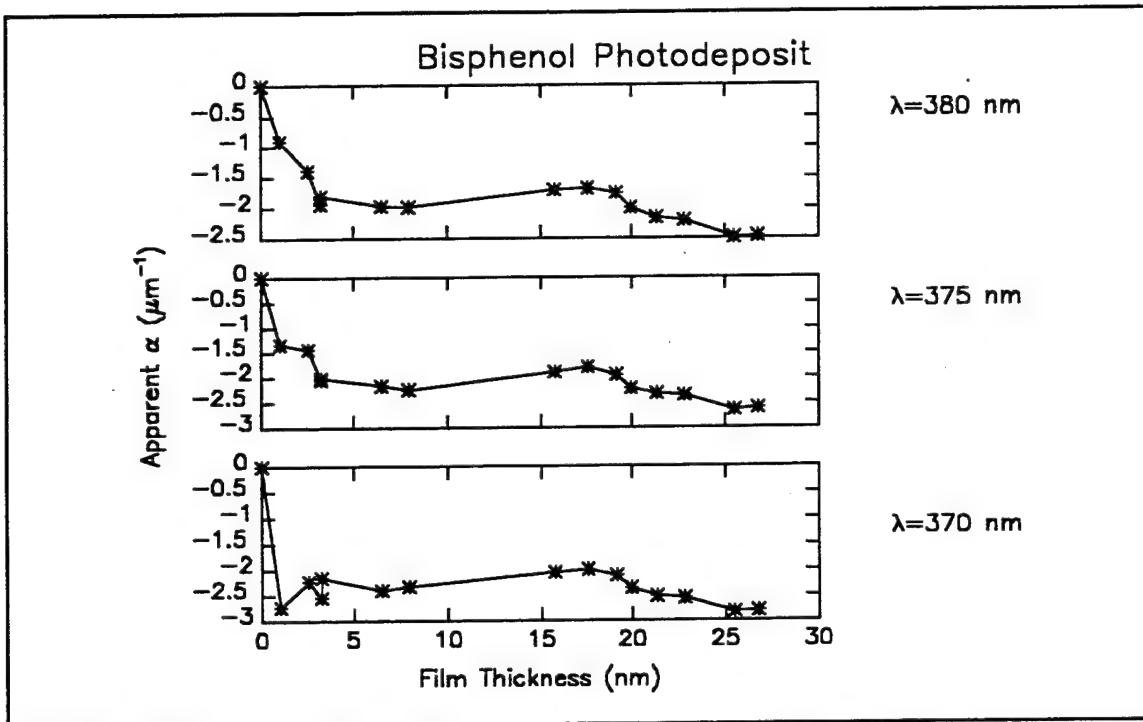


Figure A16w Computed values of α_j for the Bisphenol photodeposit, visible range.

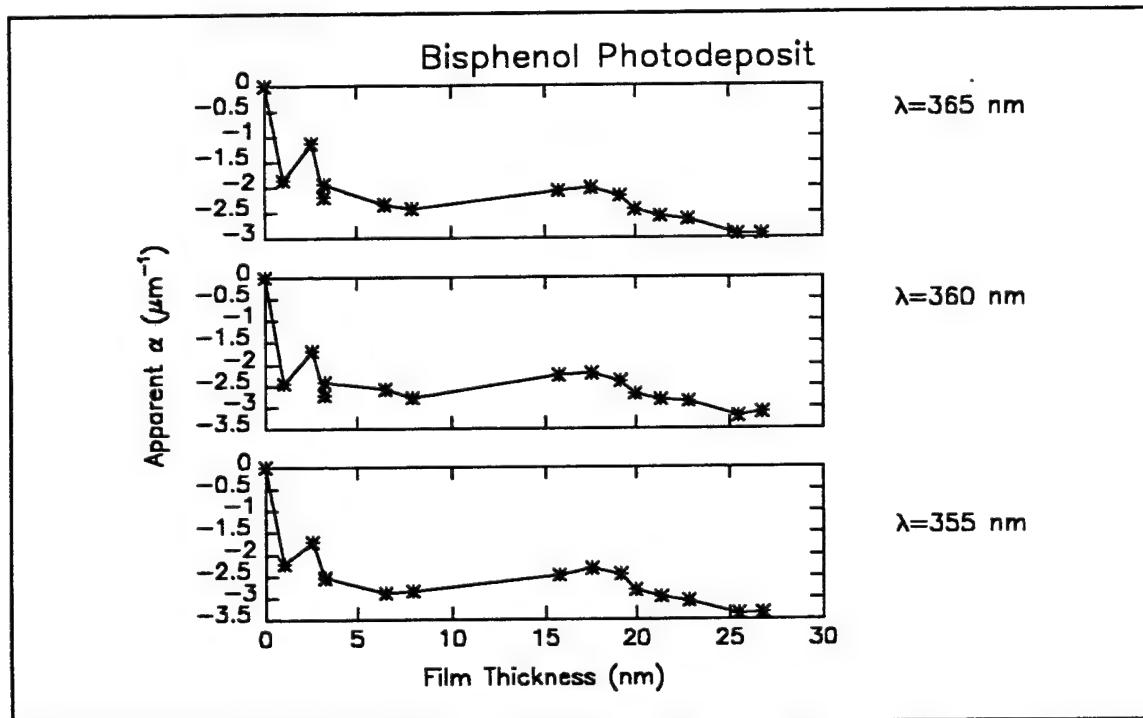


Figure A16x Computed values of α_j for the Bisphenol photodeposit, visible range.

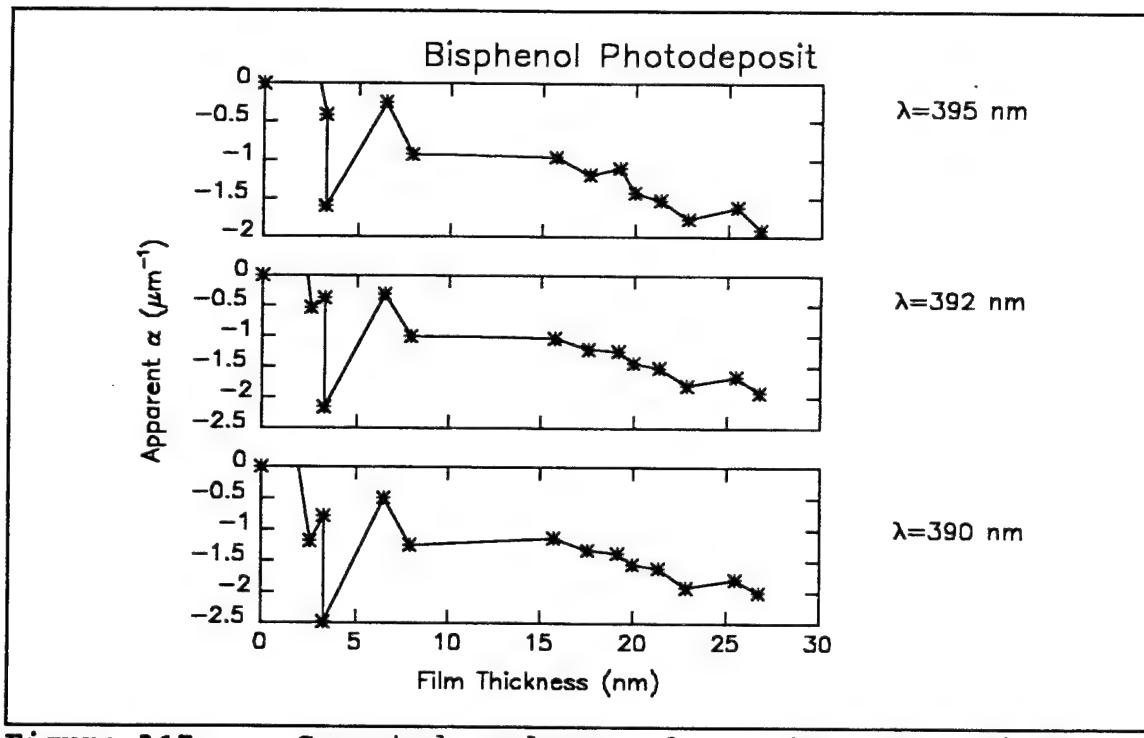


Figure A17a Computed values of α_j for the Bisphenol photodeposit, visible range.

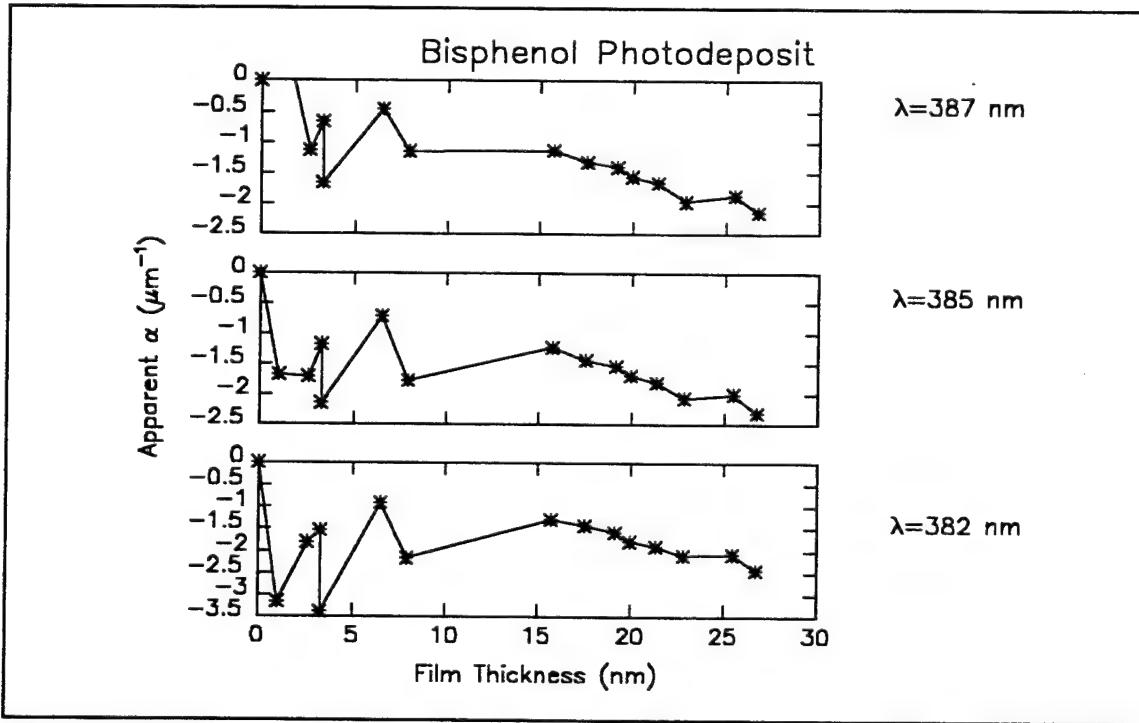


Figure A17b Computed values of α_j for the Bisphenol photodeposit, visible range.

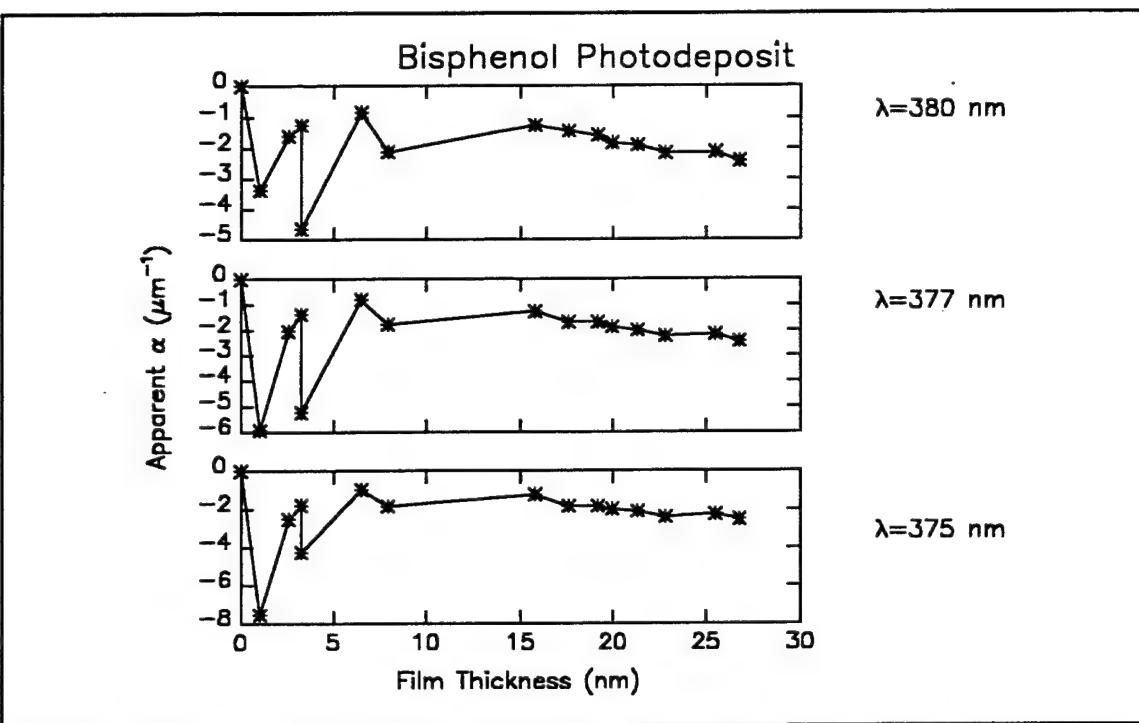


Figure A17c Computed values of α_j for the Bisphenol photodeposit, visible range.

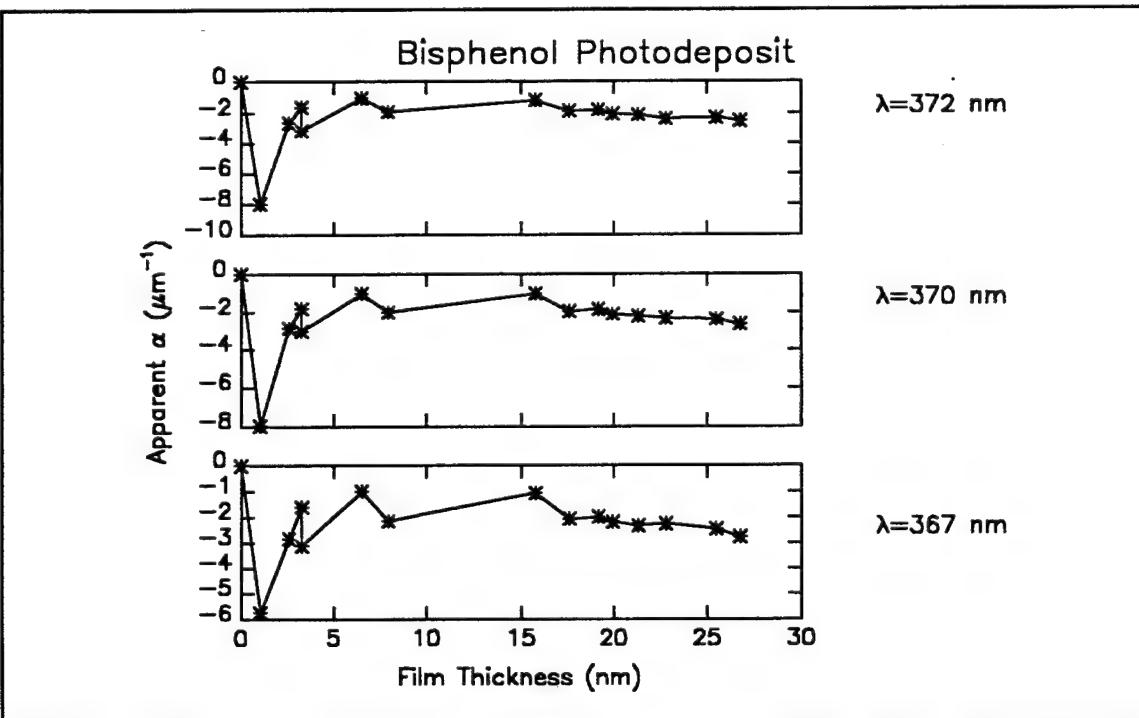


Figure A17d Computed values of α_j for the Bisphenol photodeposit, visible range.

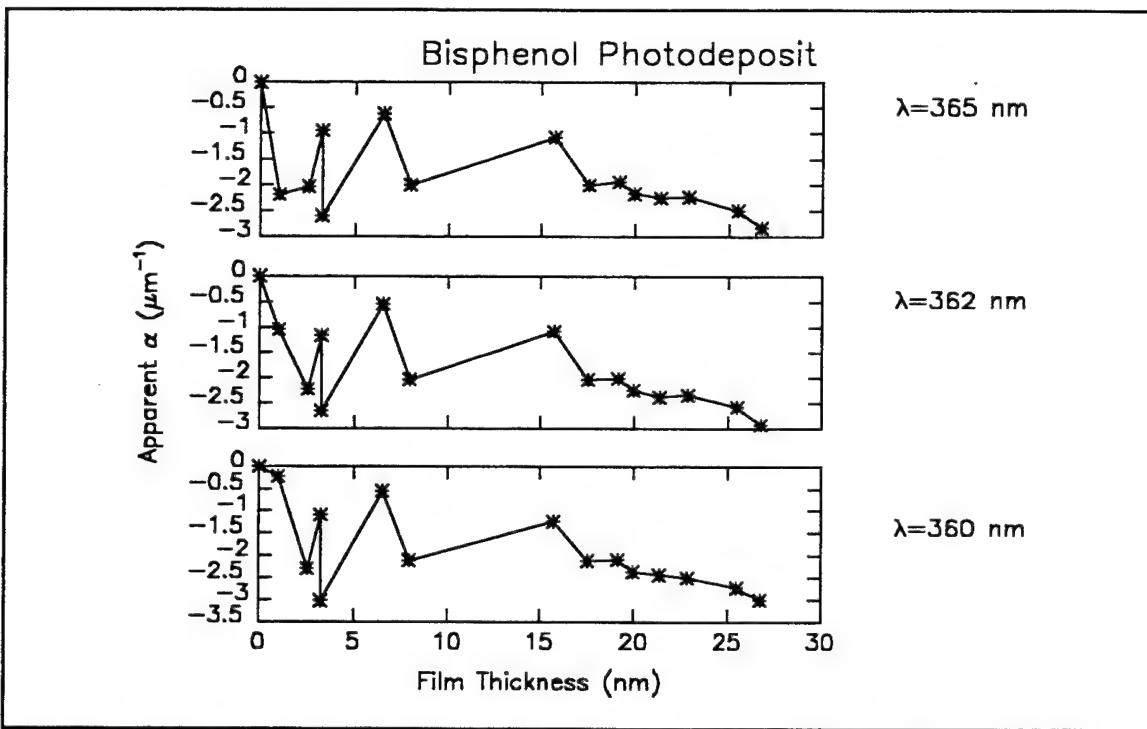


Figure A17e Computed values of α_j for the Bisphenol photodeposit, visible range.

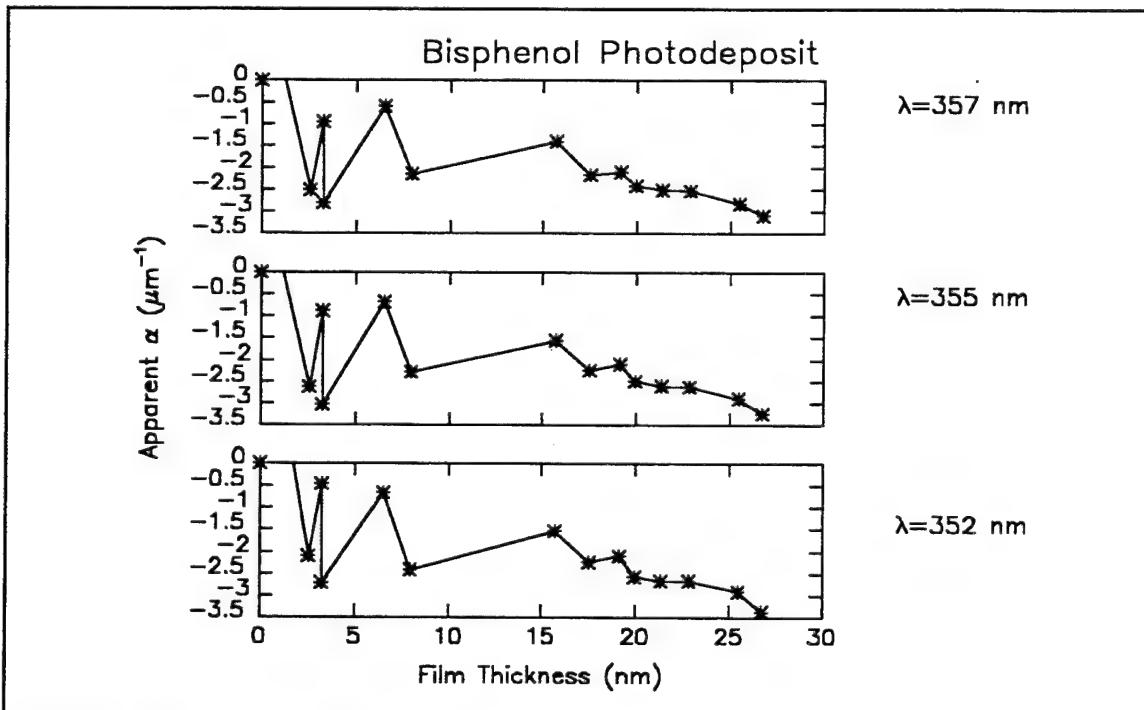


Figure A17f Computed values of α_j for the Bisphenol photodeposit, visible range.

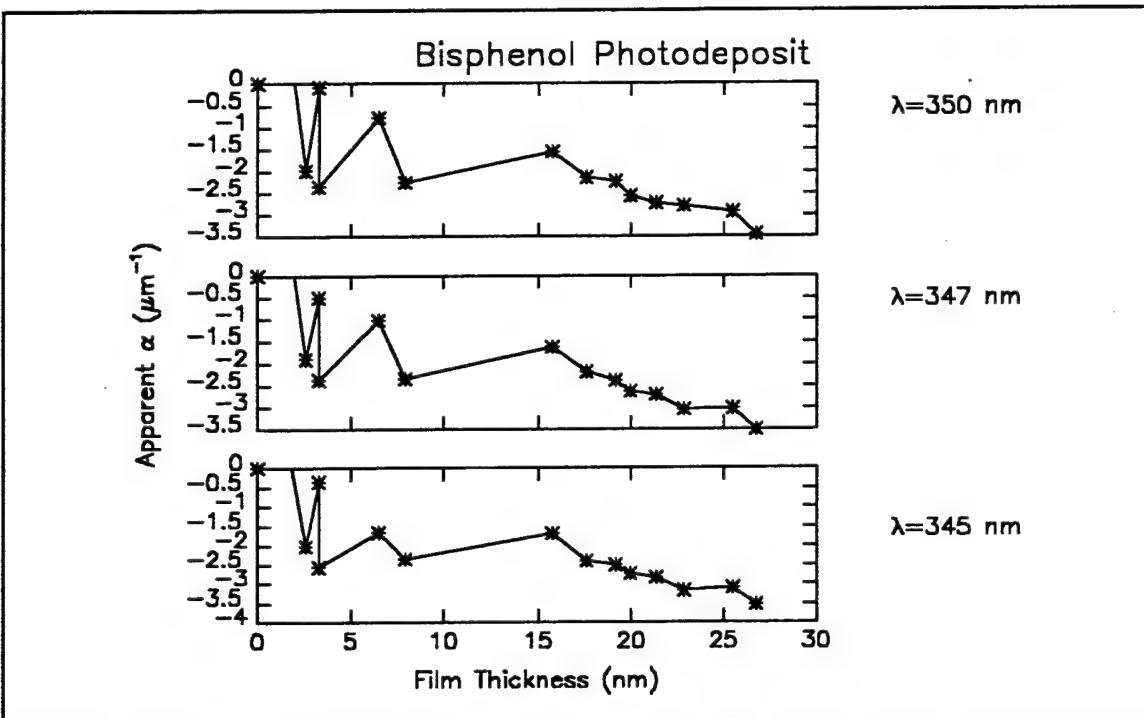


Figure A17g Computed values of α_j for the Bisphenol photodeposit, ultraviolet range.

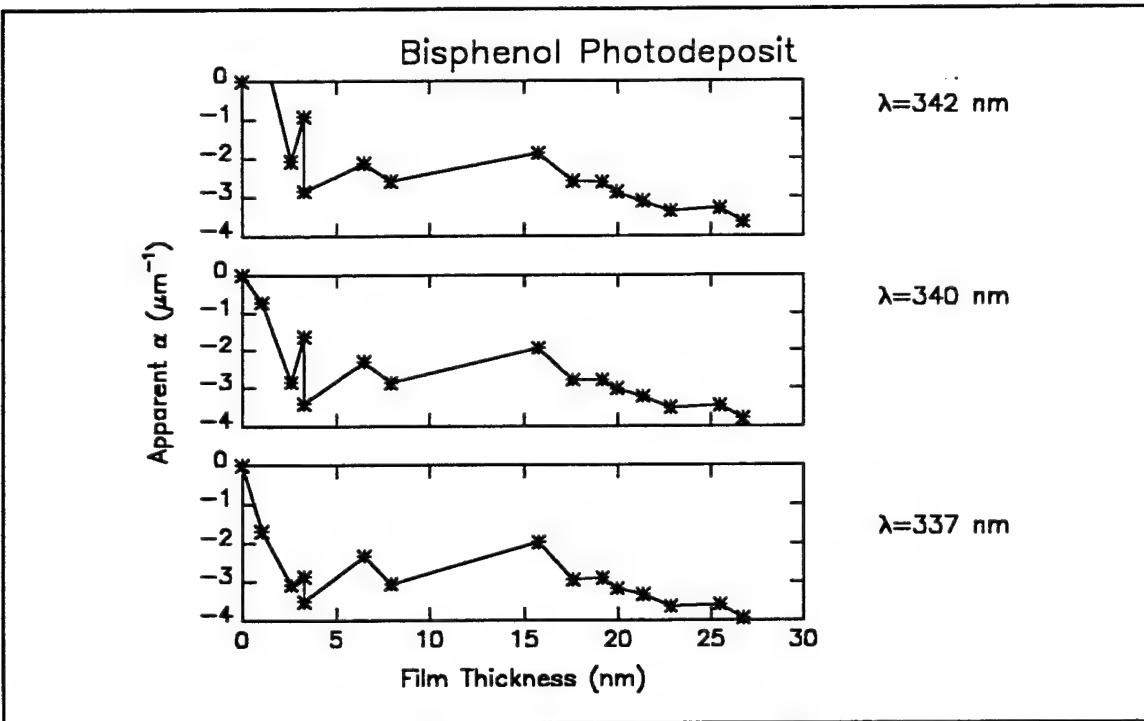


Figure A17h Computed values of α_j for the Bisphenol photodeposit, ultraviolet range.

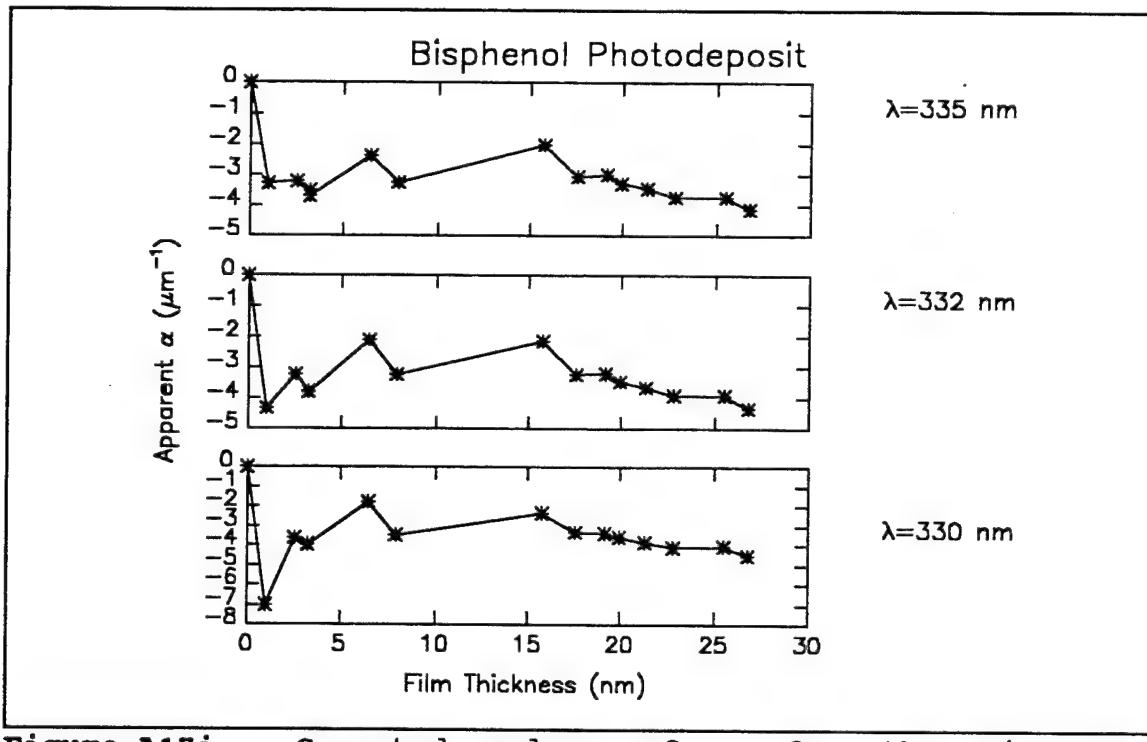


Figure A17i Computed values of α_j for the Bisphenol photodeposit, ultraviolet range.

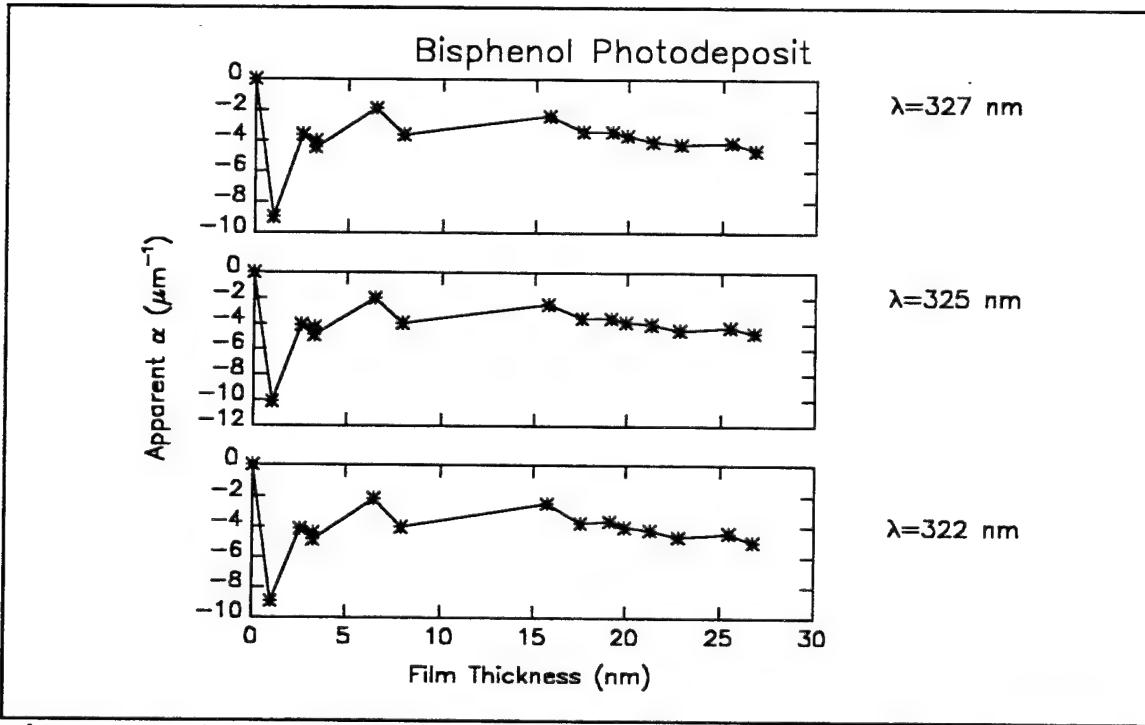


Figure A17j Computed values of α_j for the Bisphenol photodeposit, ultraviolet range.

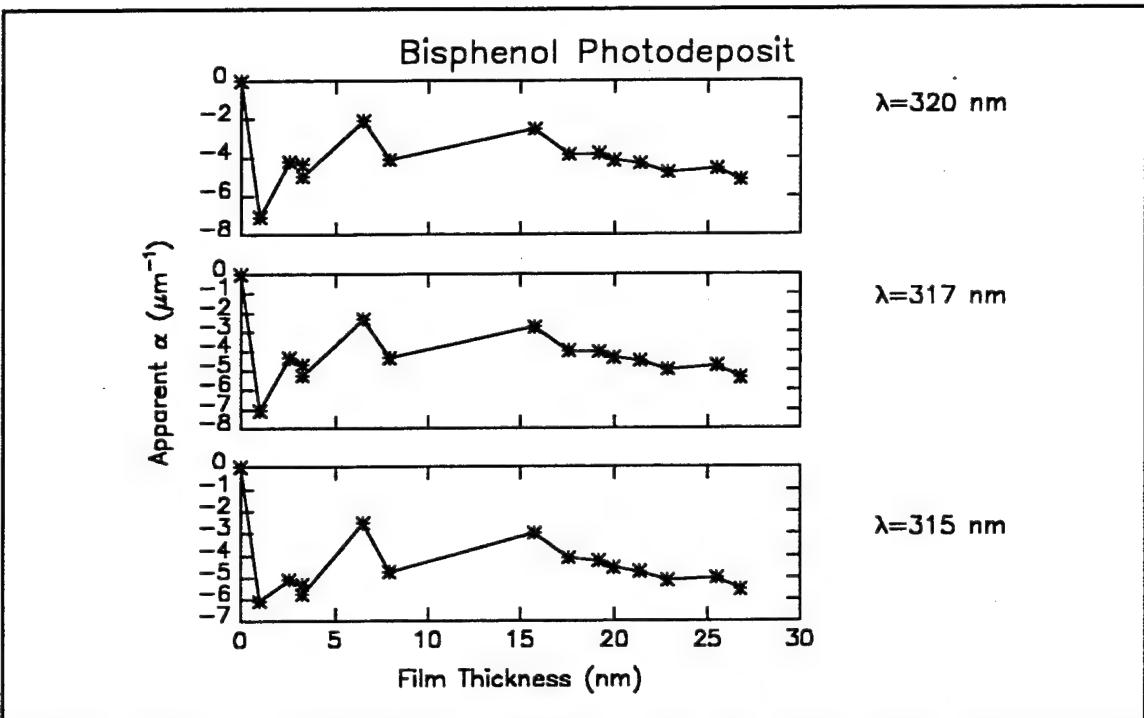


Figure A17k Computed values of α_j for the Bisphenol photodeposit, ultraviolet range.

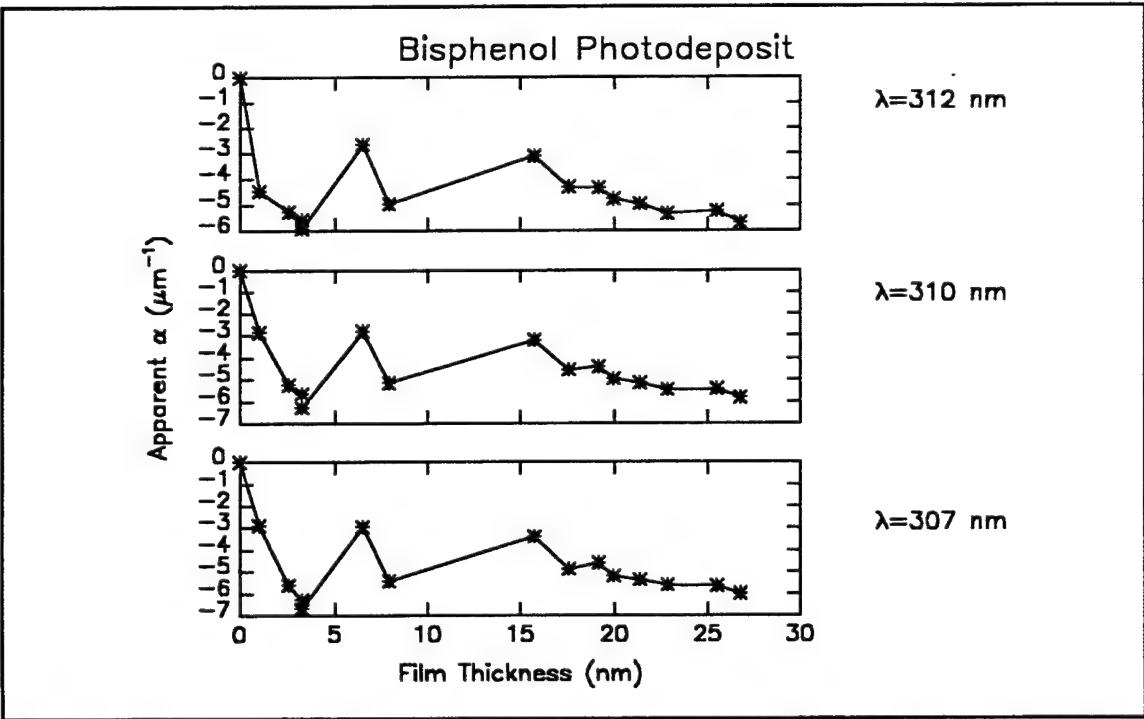


Figure A17l Computed values of α_j for the Bisphenol photodeposit, ultraviolet range.

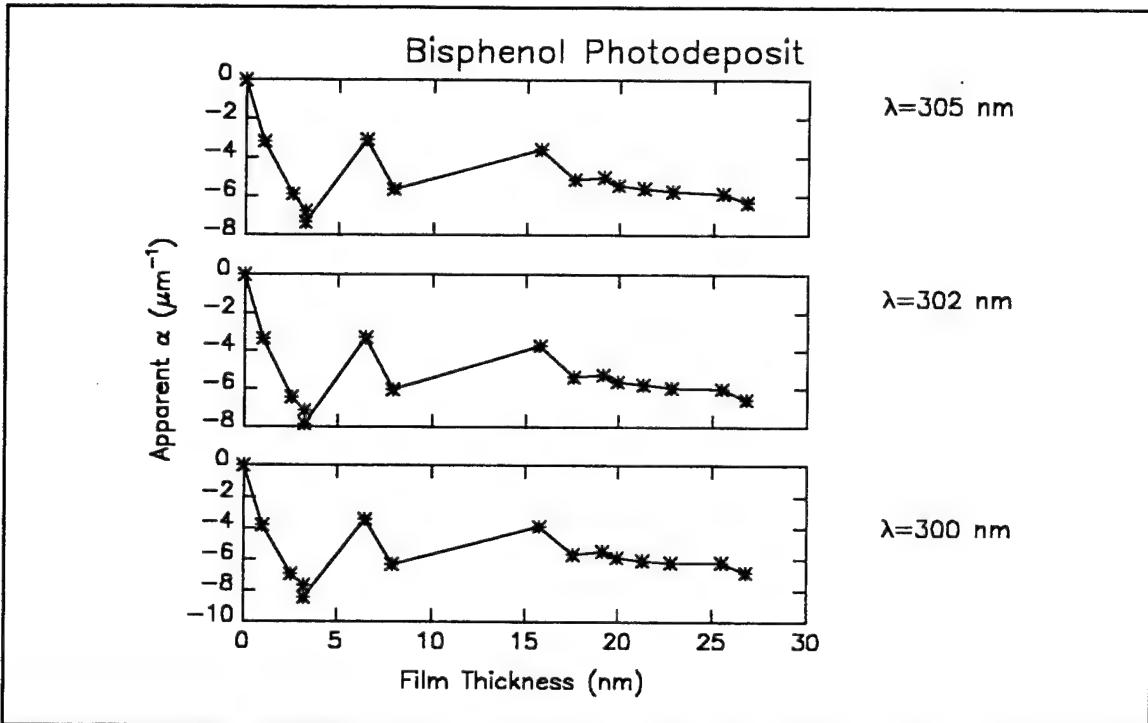


Figure A17m Computed values of α_j for the Bisphenol photodeposit, ultraviolet range.

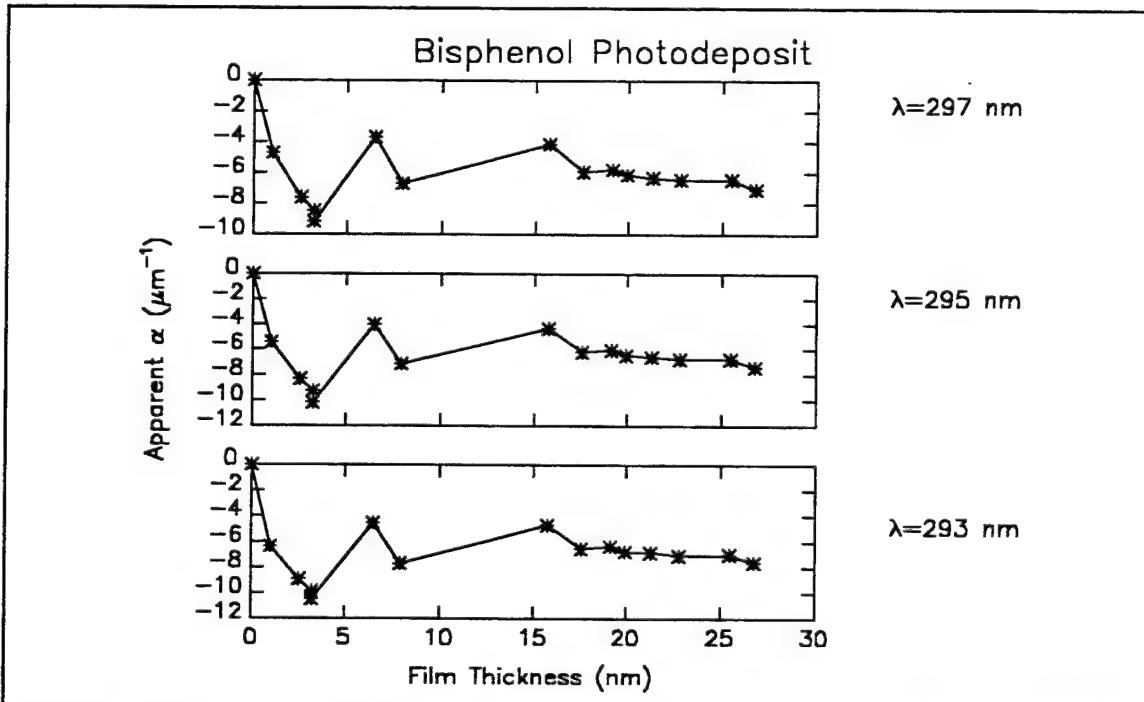


Figure A17n Computed values of α_j for the Bisphenol photodeposit, ultraviolet range.

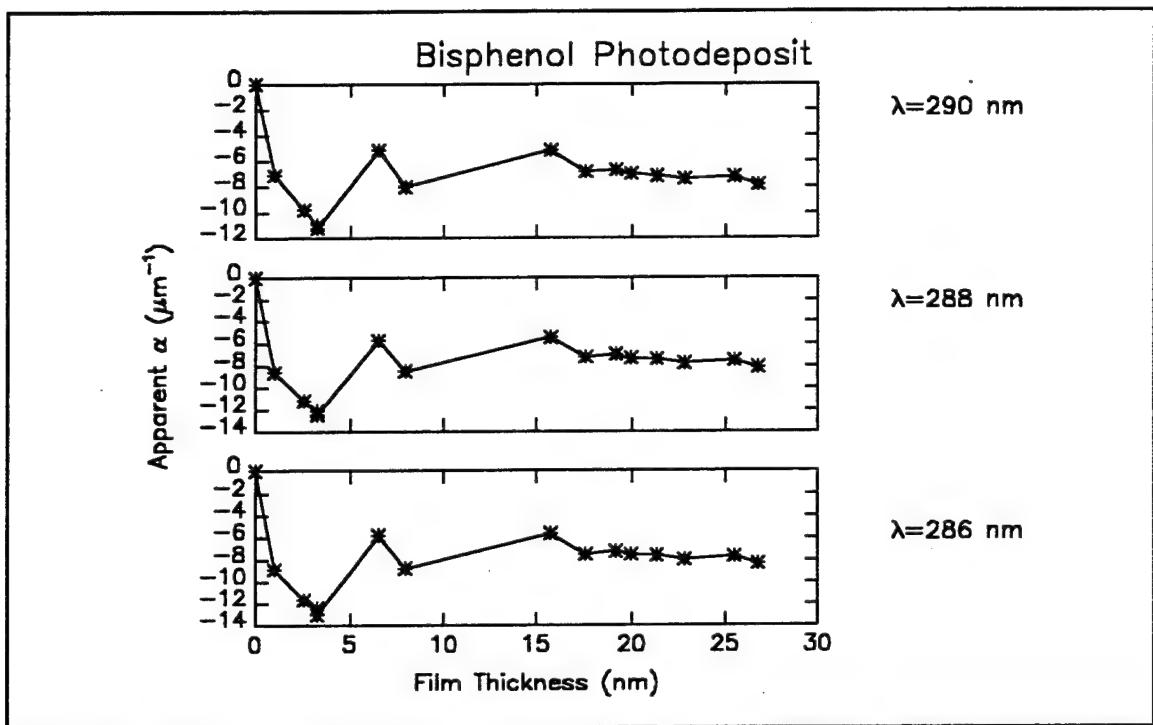


Figure A17o Computed values of α_j for the Bisphenol photodeposit, ultraviolet range.

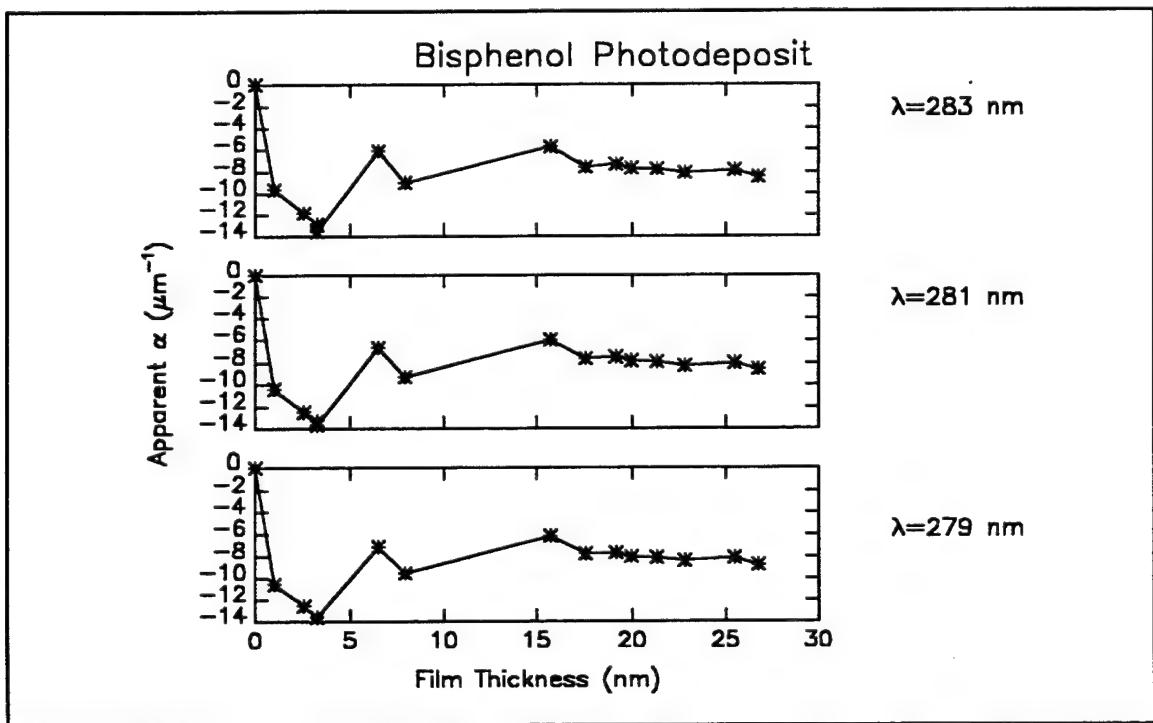


Figure A17p Computed values of α_j for the Bisphenol photodeposit, ultraviolet range.

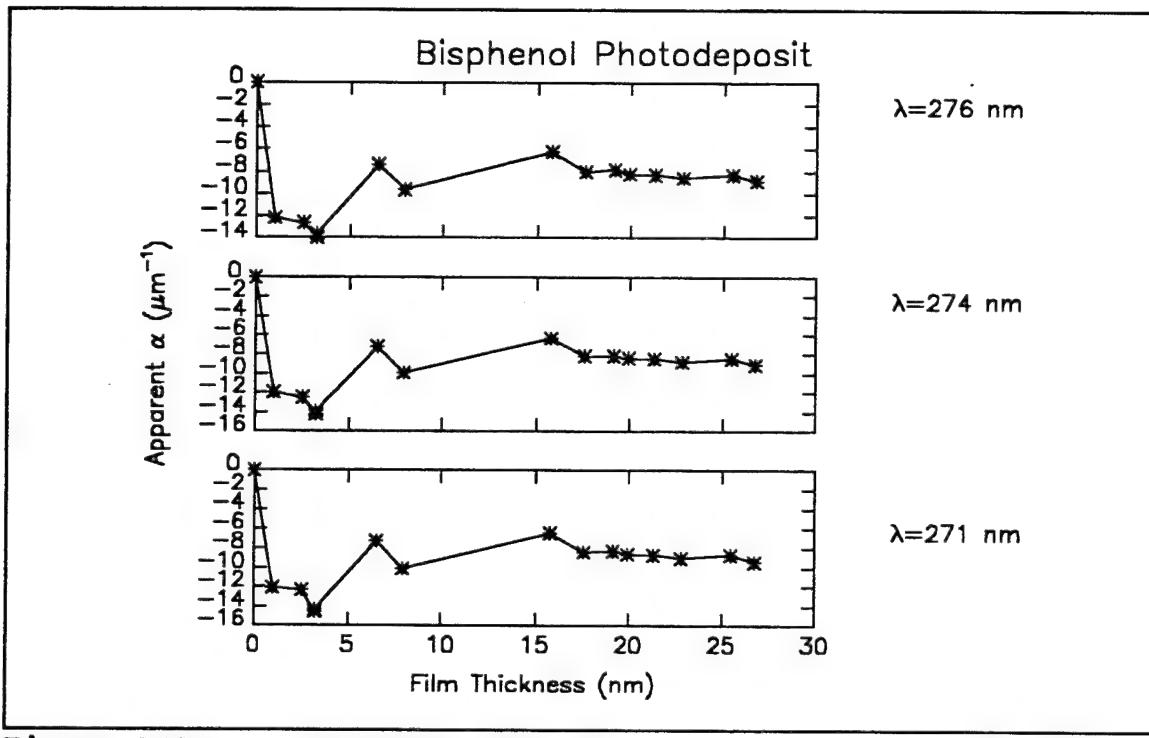


Figure A17q Computed values of α_j for the Bisphenol photodeposit, ultraviolet range.

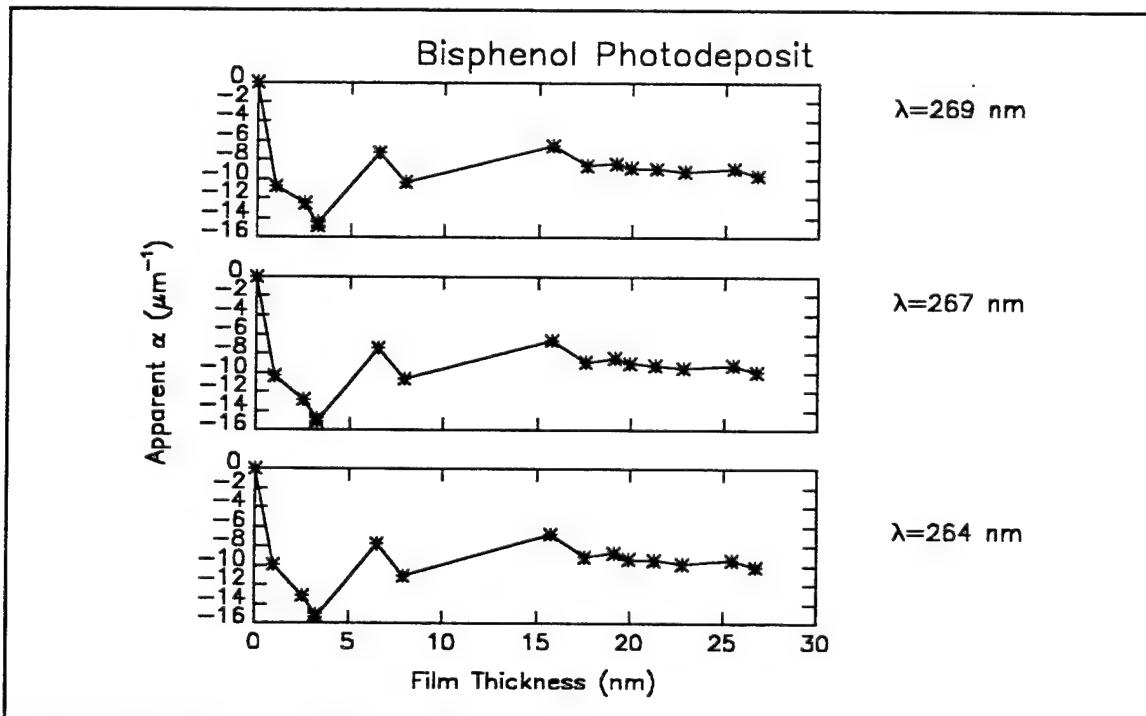


Figure A17r Computed values of α_j for the Bisphenol photodeposit, ultraviolet range.

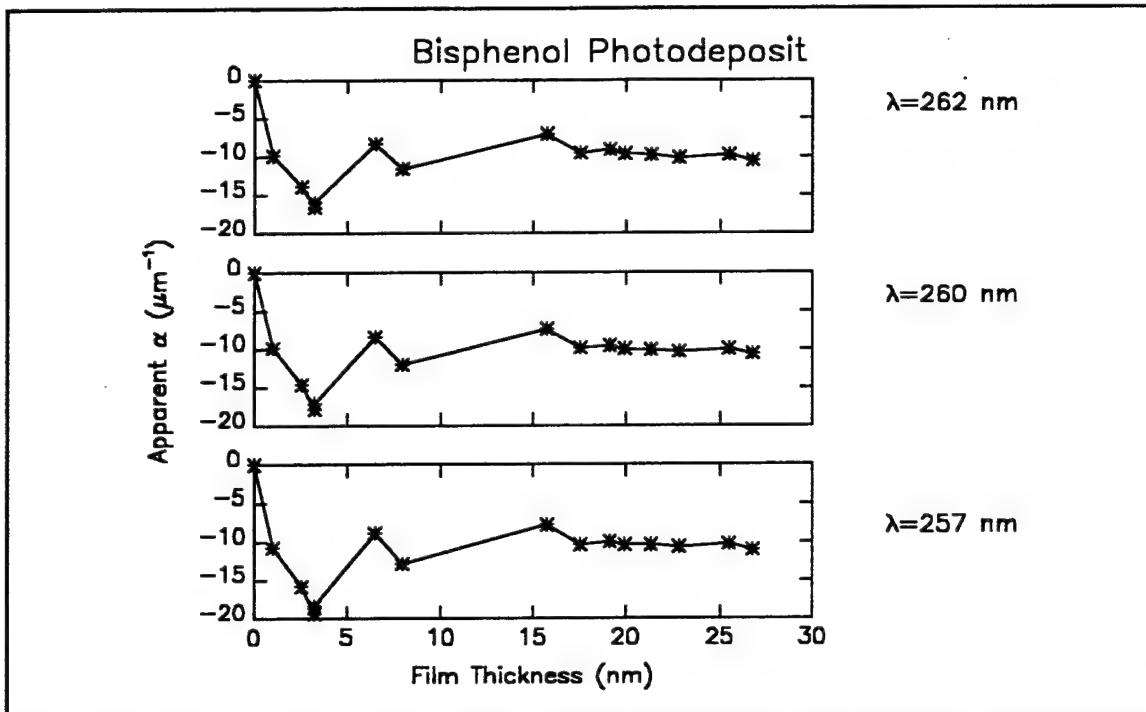


Figure A17s Computed values of α_j for the Bisphenol photodeposit, ultraviolet range.

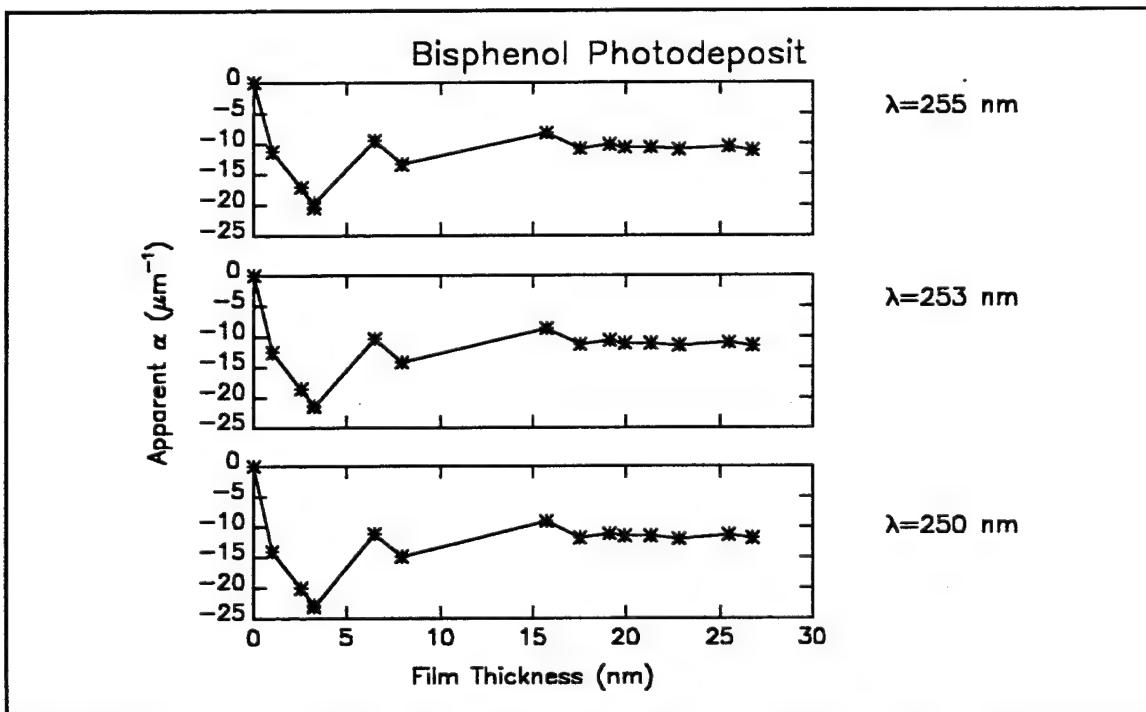


Figure A17t Computed values of α_j for the Bisphenol photodeposit, ultraviolet range.

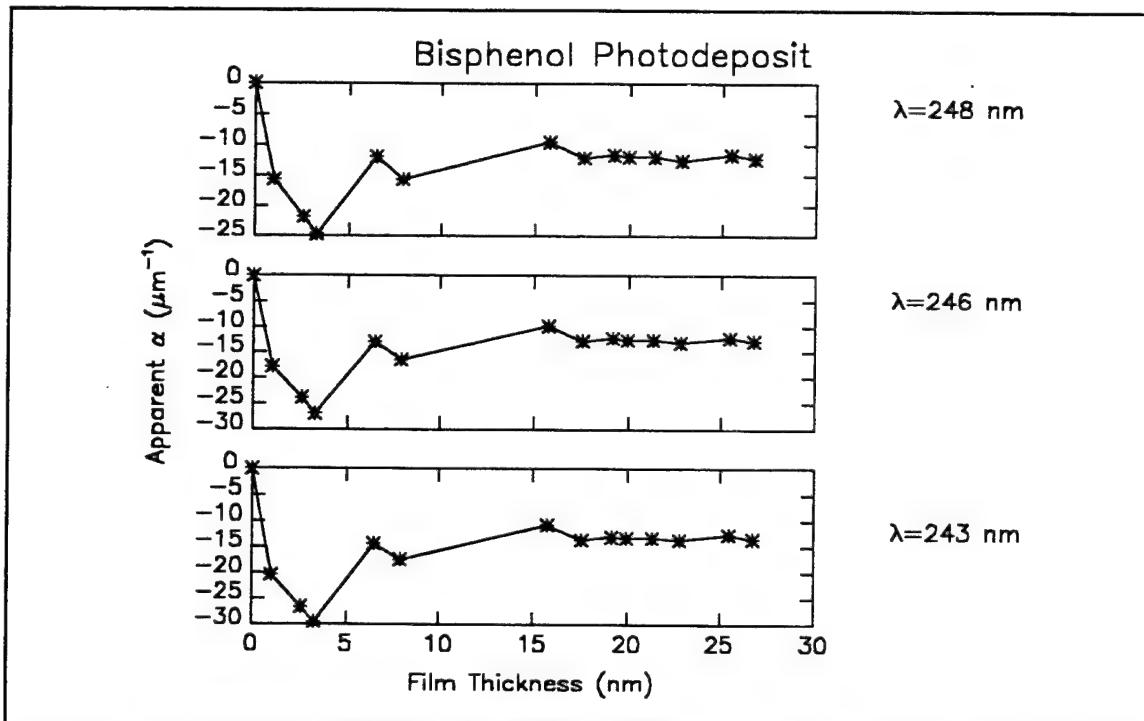


Figure A17u Computed values of α_j for the Bisphenol photodeposit, ultraviolet range.

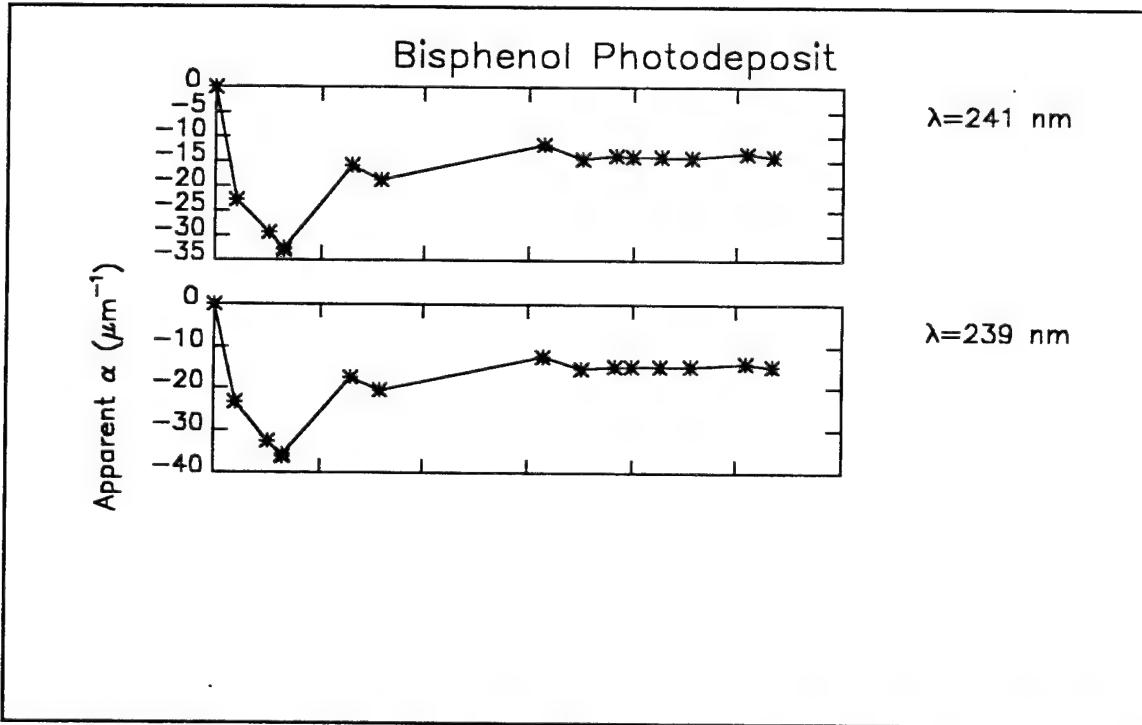


Figure A17v Computed values of α_j for the Bisphenol photodeposit, ultraviolet range.

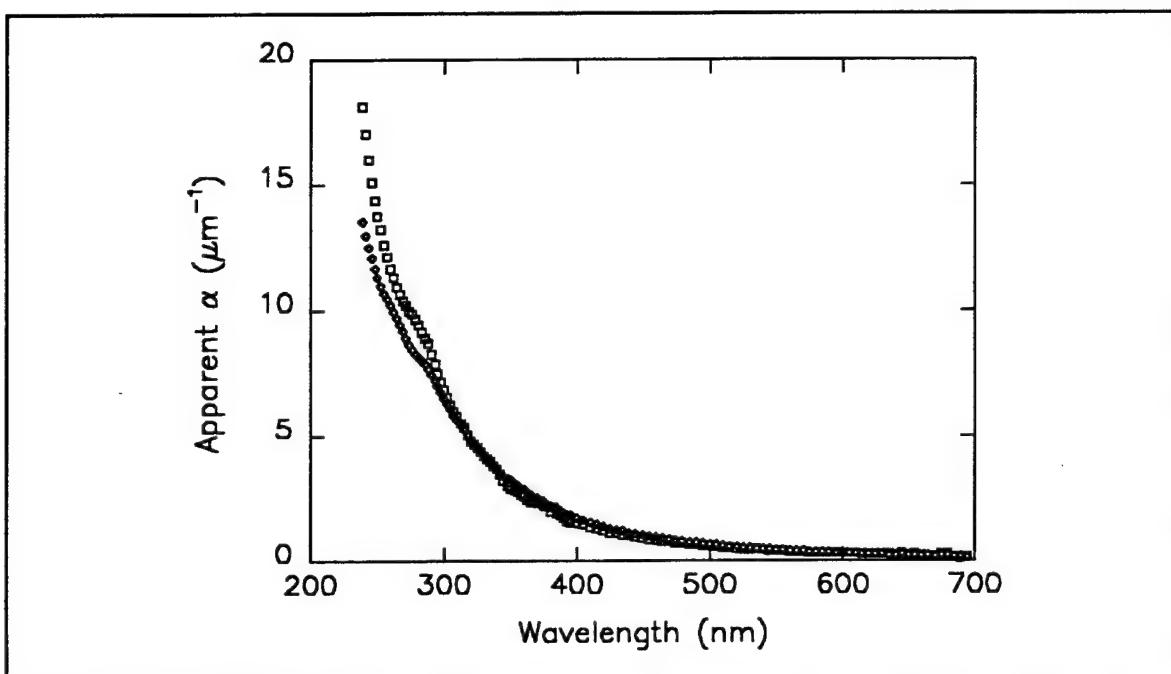


Figure A18. Apparent absorption coefficient (μm^{-1}) of the bisphenol photodeposit, linear plot. Squares, averaging for thick films. Diamonds, Beer's law fit of the entire data set.

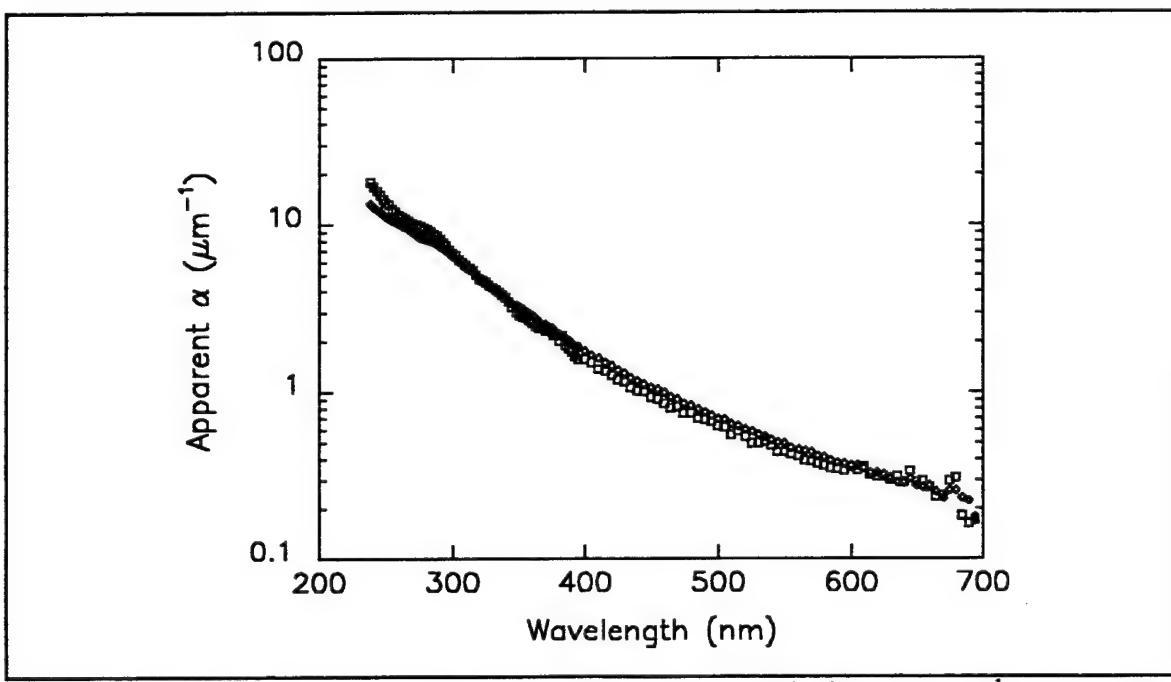


Figure A19. Apparent absorption coefficient (μm^{-1}) of the bisphenol photodeposit, log plot. Squares, averaging for thick films. Diamonds, Beer's law fit of the entire data set.

Appendix B—DC704

SPECTRA AND FIT RESULTS FOR THE DC704 PHOTODEPOSIT

This appendix archives the deposition data and transmission spectra measured during a roughly 30 day continuous experiment in which a contaminant film was photochemically deposited from the precursor material tetramethyltetraphenyltrisiloxane, or DC704. This model contaminant serves as an analog for the materials that outgas from silicone adhesives, rubbers, and potting compounds.

1.0 DEPOSITION DATA AND TRANSMISSION SPECTRA

Figure B1 shows the TQCM data measured during the photochemical deposition of DC704. During the first 150 hours of deposition, the film grew at a rate of about 5 Hz/hour (1 nm/hour). During the latter 500 hours of deposition the rate was about 2 Hz/hour (0.08 nm/hour).

The nominal film thickness was calculated assuming a density equal to that of the starting material and a TQCM calibration coefficient of 4.43 ng/cm²/Hz. Table B1 shows the nominal thicknesses at which visible (695-355 nm) transmission spectra were measured. Table B2 shows the nominal thicknesses at which ultraviolet transmission spectra (395-235 nm) were measured.

Table B1 Nominal film thicknesses, nm, at which visible wavelength range spectra were measured.

0.0	0.0	6.4	12.0	16.5	17.8	25.6	28.4	29.2
30.8	32.5	32.4	38.4	39.7	41.2	42.0	43.3	45.3
46.4	47.6	48.8	50.1	51.9	54.9	54.4	54.3	54.3

Table B2 Nominal film thicknesses, nm, at which ultraviolet wavelength range spectra were measured.

0.0	0.0	6.4	12.0	16.4	17.8	25.6	29.2	30.8
32.4	38.4	39.7	41.2	42.0	43.3	45.2	46.3	47.6
48.7	50.0	51.9	54.9	54.4	54.2			

The transmission spectra are plotted in Figures B2 through B12. Where multiple measurements were made at a single thickness, the data are overplotted.

2.0 BEER'S LAW FITS

The transmission spectra were fit to the Beer-Lambert absorption law,

$$\log_e(I/I_0) = -\alpha t \quad (B1)$$

where I/I_0 is the transmittance of the film, t is the film thickness, and α is the absorption coefficient of the film. The transmittance of the film was calculated as the ratio of the transmission of the deposit, on the substrate, to the transmission of the clean substrate. Note that the quantity $\log(I/I_0)$ will be called the film absorbance.

Figures B13 and B14 present the results of this analysis. The linear least-squares fits were not constrained to pass through the origin. Figure B15 shows the ratio of the fitted intercept to the absolute value of the largest absorbance measured. The negative values in this plot are indicative the downward curvature of plots of absorbance vs. thickness. The actual fits are shown in Figure B16 for the visible wavelengths, and B17 for the ultraviolet wavelengths.* Tables B2 and B3 present the results of the visible and ultraviolet fits, respectively.

The plots shown in Figures B16 and B17 show a distinct downward curvature for the wavelengths of strong absorption. This curvature is understood to be the result of the slower film deposition during the later part of the experiment, resulting in a more fully darkened film.

3.0 CONSTRAINED FITS

Because of the curvature of the absorbance vs. thickness plots, a second approach was used to extract an apparent absorption coefficient from the data. In this case, the "Beer's law plot" is constrained to pass through the origin by calculating an apparent α as

* Note that the plots show the absorption coefficient as a negative number, which is opposite to the sign convention shown in equation B1.

$$\alpha = \langle \alpha_j \rangle = \frac{1}{j_f - j_i + 1} \sum_{j=j_i}^{j=j_f} \frac{\log_e[I(t_j)/I_0]}{t_j} \quad (B2)$$

where I/I_0 is the transmittance of the film, t_j is the film thickness for the j th measurement, and α is the absorption coefficient of the film. The transmittance of the film was calculated as the ratio of the transmission of the deposit, on the substrate, to the transmission of the clean substrate.

Figures B18 and B19 present the results of this analysis, where the average was performed for film thicknesses of 26 nm and greater. The constrained data (α_j) are shown in Figure B20 for the visible wavelengths, and B21 for the ultraviolet wavelengths. Tables B5 and B6 present the results of the visible and ultraviolet fits, respectively.

4.0 COMPARISON OF THE FITS

Figures B22 and B23 provide comparisons of the apparent absorption coefficients obtained from the two fitting approaches. They are everywhere in agreement to within better than a factor of two. Since the constrained fits are not as severely biased by the continued darkening of the film during deposition, they will generally be used in estimating the effects of this type of contaminant film on optical and thermal control surfaces.

Table B3. Beer's law fit results for the DC704 photodeposit, visible wavelength range.

Wavelength (nm)	Absorption Coefficient (μm^{-1})	Intercept (see plot)
695	0.37	0.000
690	0.39	-0.005
685	0.42	-0.005
680	0.42	-0.005
675	0.45	-0.005
670	0.45	-0.006
665	0.47	-0.005
660	0.49	-0.004
655	0.49	-0.004
650	0.50	-0.004
645	0.51	-0.004
640	0.52	-0.005
635	0.53	-0.005
630	0.54	-0.004
625	0.54	-0.005
620	0.55	-0.005
615	0.55	-0.006
610	0.56	-0.006
605	0.56	-0.006
600	0.57	-0.006
595	0.57	-0.006
590	0.58	-0.007
585	0.59	-0.008
580	0.59	-0.008
575	0.59	-0.008
570	0.60	-0.009

Table B3, continued

Wavelength (nm)	Absorption Coefficient (μm^{-1})	Intercept (see plot)
565	0.60	-0.009
560	0.60	-0.009
555	0.62	-0.009
550	0.63	-0.010
545	0.64	-0.010
540	0.66	-0.010
535	0.67	-0.010
530	0.70	-0.010
525	0.72	-0.010
520	0.76	-0.010
515	0.80	-0.009
510	0.86	-0.009
505	0.92	-0.009
500	0.98	-0.008
495	1.07	-0.008
490	1.16	-0.007
485	1.26	-0.005
480	1.38	-0.004
475	1.51	-0.003
470	1.65	-0.001
465	1.81	0.001
460	1.98	0.002
455	2.17	0.004
450	2.37	0.006
445	2.58	0.009
440	2.81	0.012
435	3.06	0.014

Table B3, continued

Wavelength (nm)	Absorption Coefficient (μm^{-1})	Intercept (see plot)
430	3.31	0.017
425	3.58	0.020
420	3.86	0.022
415	4.14	0.025
410	4.43	0.027
405	4.75	0.031
400	5.06	0.033
395	5.40	0.036
390	5.74	0.040
385	6.11	0.042
380	6.49	0.045
375	6.89	0.049
370	7.32	0.053
365	7.78	0.057
360	8.25	0.060
355	8.75	0.064

Table B4. Beer's law fit results for the DC704 photodeposit, ultraviolet wavelength range.

Wavelength (nm)	Absorption Coefficient (μm^{-1})	Intercept (see plots)
395.0	5.2	0.03
392.5	5.4	0.03
390.0	5.6	0.03
387.5	5.8	0.03

Table B4, continued

Wavelength (nm)	Absorption Coefficient (μm^{-1})	Intercept (see plots)
385.0	6.0	0.03
382.5	6.1	0.04
380.0	6.3	0.04
377.5	6.5	0.04
375.0	6.7	0.04
372.5	6.9	0.04
370.0	7.1	0.04
367.5	7.3	0.04
365.0	7.5	0.05
362.5	7.8	0.05
360.0	8.0	0.05
357.5	8.2	0.05
355.0	8.5	0.05
352.5	8.7	0.06
350.0	9.0	0.06
347.5	9.3	0.06
345.0	9.5	0.06
342.5	9.8	0.06
340.0	10.1	0.07
337.5	10.4	0.07
335.0	10.6	0.07
332.5	10.9	0.07
330.0	11.2	0.08
327.5	11.5	0.08
325.0	11.8	0.08
322.5	12.1	0.08
320.0	12.4	0.09

Table B4, continued

Wavelength (nm)	Absorption Coefficient (μm^{-1})	Intercept (see plots)
317.5	12.7	0.09
315.0	13.0	0.09
312.5	13.4	0.09
310.0	13.8	0.10
307.5	14.2	0.10
305.0	14.7	0.10
302.5	15.1	0.10
300.0	15.6	0.11
297.5	16.1	0.11
295.0	16.7	0.12
292.5	17.3	0.12
290.0	17.9	0.12
287.5	18.6	0.13
285.0	19.3	0.13
282.5	20.1	0.14
280.0	20.9	0.14
277.5	21.7	0.15
275.0	22.7	0.15
272.5	23.8	0.16
270.0	24.5	0.16
267.5	25.2	0.17
265.0	25.9	0.17
262.5	26.3	0.18
260.0	26.9	0.18
257.5	27.2	0.18
255.0	27.9	0.19
252.5	28.7	0.19

Table B4, continued

Wavelength (nm)	Absorption Coefficient (μm^{-1})	Intercept (see plots)
250.0	29.7	0.20
247.5	31.2	0.21
245.0	33.1	0.23
242.5	35.5	0.24
240.0	38.8	0.27
237.5	43.0	0.30
235.0	48.5	0.34

Table B5. Apparent absorption coefficients from the constrained fits, visible wavelengths.

Wavelength (nm)	Apparent α (μm^{-1})
695	0.60
690	0.64
685	0.66
680	0.68
675	0.69
670	0.71
665	0.70
660	0.70
655	0.71
650	0.72
645	0.72
640	0.74
635	0.74
630	0.75

Table B5, continued

Wavelength (nm)	Apparent α (μm^{-1})
625	0.76
620	0.77
615	0.77
610	0.79
605	0.80
600	0.81
595	0.82
590	0.84
585	0.86
580	0.85
575	0.87
570	0.88
565	0.89
560	0.90
555	0.92
550	0.94
545	0.96
540	0.98
535	0.99
530	1.0
525	1.0
520	1.1
515	1.1
510	1.2
505	1.2
500	1.2
495	1.3
490	1.4

Table B5, continued

Wavelength (nm)	Apparent α (μm^{-1})
485	1.4
480	1.5
475	1.6
470	1.7
465	1.8
460	1.9
455	2.0
450	2.1
445	2.3
440	2.4
435	2.6
430	2.7
425	2.9
420	3.1
415	3.3
410	3.5
405	3.7
400	4.0
395	4.2
390	4.5
385	4.7
380	5.0
375	5.3
370	5.6
365	6.0
360	6.3
355	6.7

Table B6. Apparent absorption coefficients from the constrained fits, ultraviolet wavelengths.

Wavelength (nm)	Apparent α (μm^{-1})
395.0	4.3
392.5	4.4
390.0	4.5
387.5	4.7
385.0	4.8
382.5	5.0
380.0	5.1
377.5	5.2
375.0	5.4
372.5	5.5
370.0	5.7
367.5	5.9
365.0	6.0
362.5	6.2
360.0	6.4
357.5	6.6
355.0	6.8
352.5	7.0
350.0	7.2
347.5	7.4
345.0	7.5
342.5	7.8
340.0	7.9
337.5	8.2
335.0	8.4
332.5	8.6

Table B6, continued

Wavelength (nm)	Apparent α (μm^{-1})
330.0	8.8
327.5	9.0
325.0	9.3
322.5	9.5
320.0	9.7
317.5	10.0
315.0	10.3
312.5	10.6
310.0	10.9
3307.5	11.2
305.0	11.6
302.5	11.9
300.0	12.3
297.5	12.8
295.0	13.2
292.5	13.7
290.0	14.2
287.5	14.8
285.0	15.3
282.5	15.9
280.0	16.6
277.5	17.3
275.0	18.1
272.5	19.0
270.0	19.5
267.5	20.2
265.0	20.8

Table B6, continued

Wavelength (nm)	Apparent α (μm^{-1})
262.5	21.0
260.0	21.5
257.5	21.8
255.0	22.3
252.5	22.9
250.0	23.7
247.5	24.8
245.0	26.3
242.5	28.2
240.0	30.7
237.5	34.0

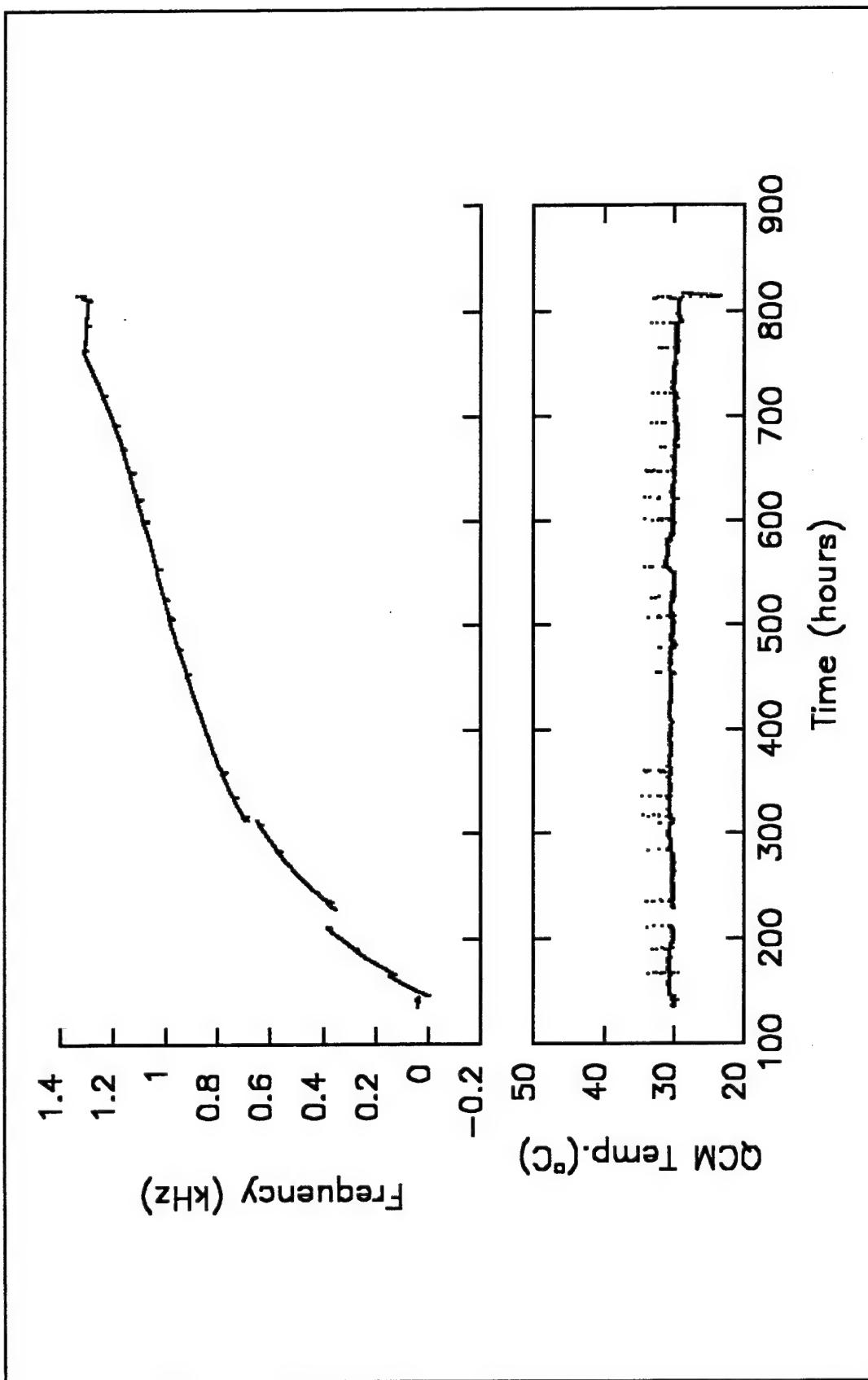


Figure B1 QCM data measured during the photochemical deposition of tetramethyltetraphenyltrisiloxane (DC704).

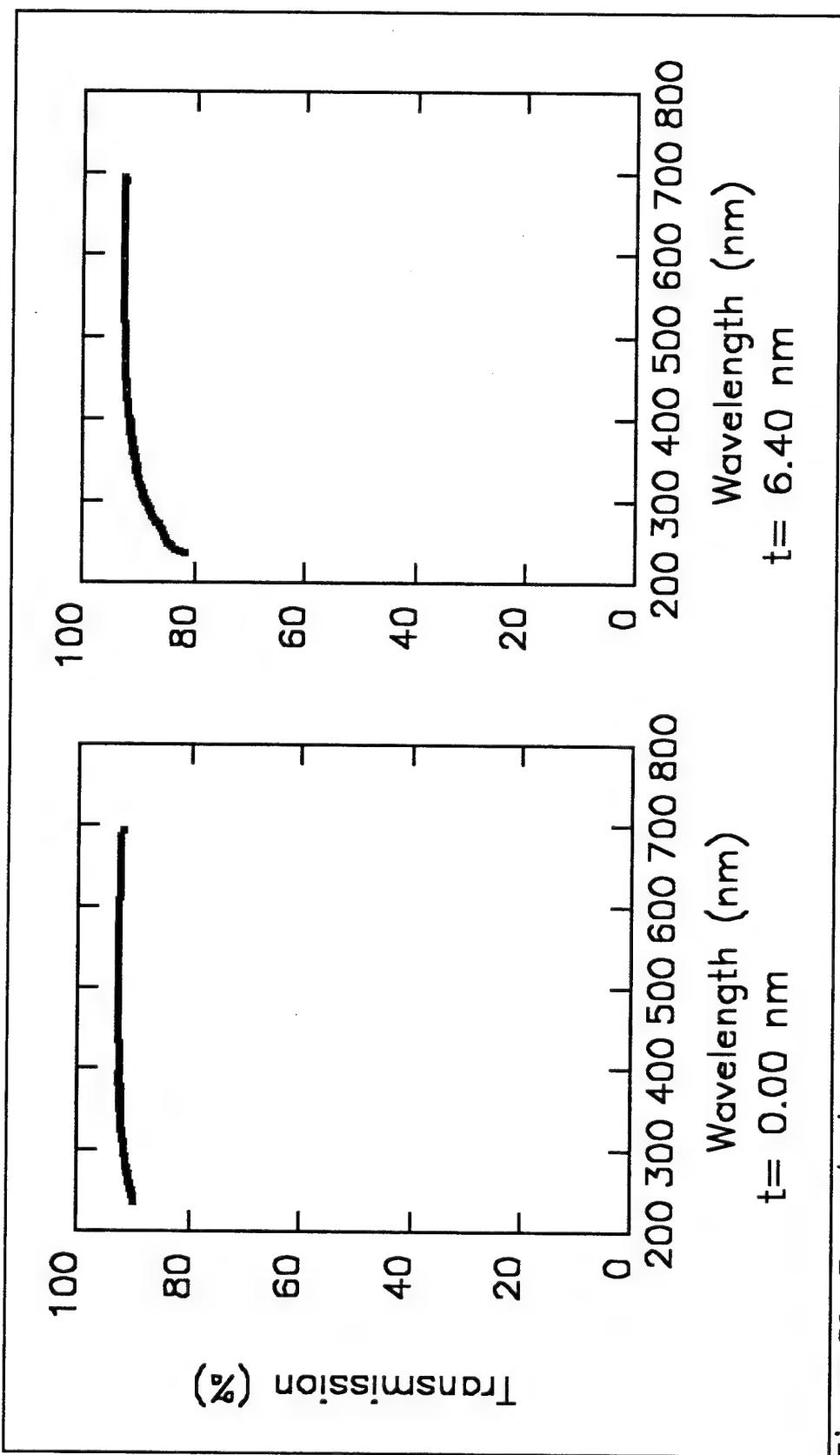


Figure B2 Transmission spectra measured during photodeposition of tetramethyltetraphenyltrisiloxane, DC704.

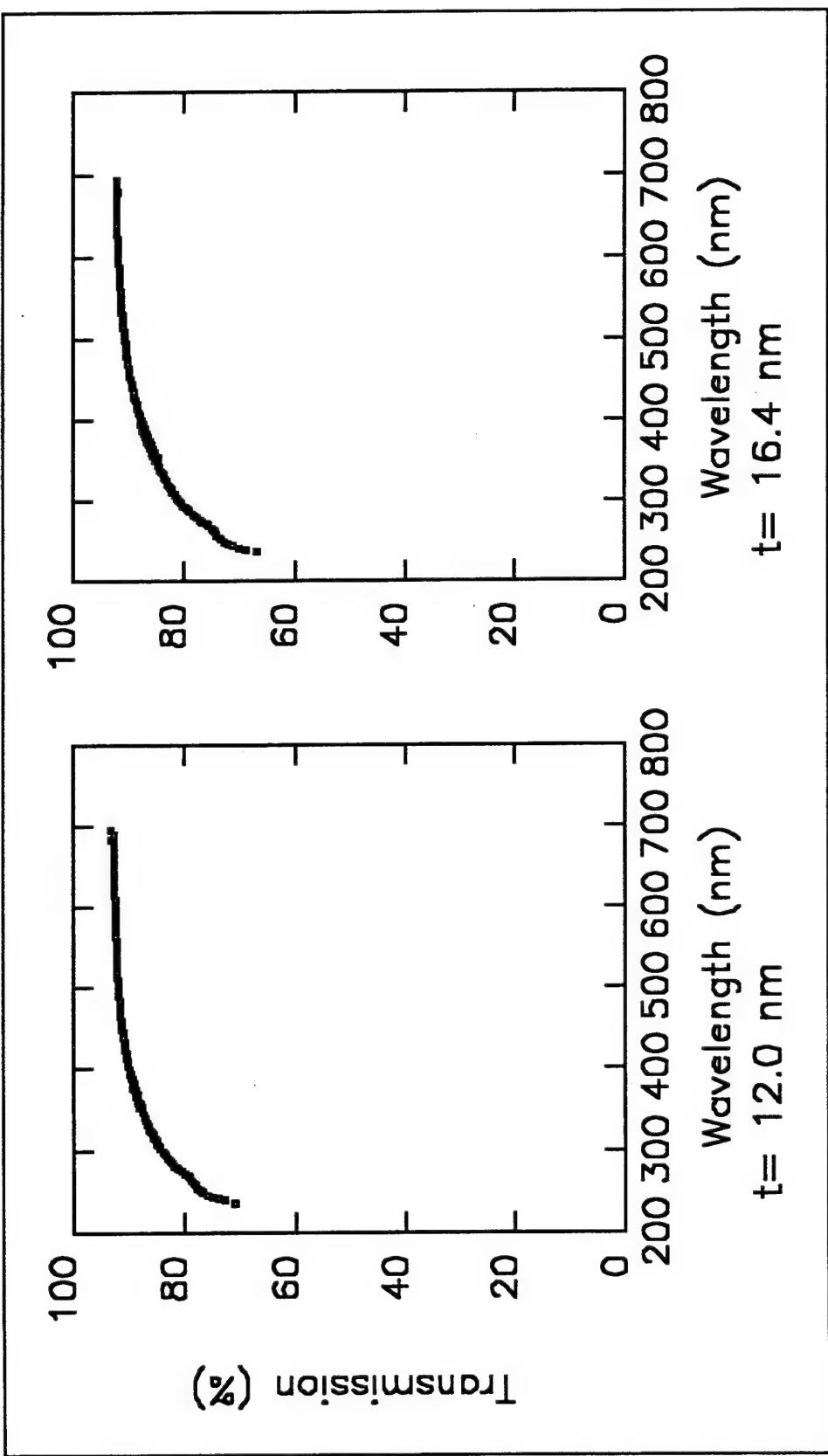


Figure B3 Transmission spectra measured during photodeposition of tetramethyltetraphenyltrisiloxane, DC704.

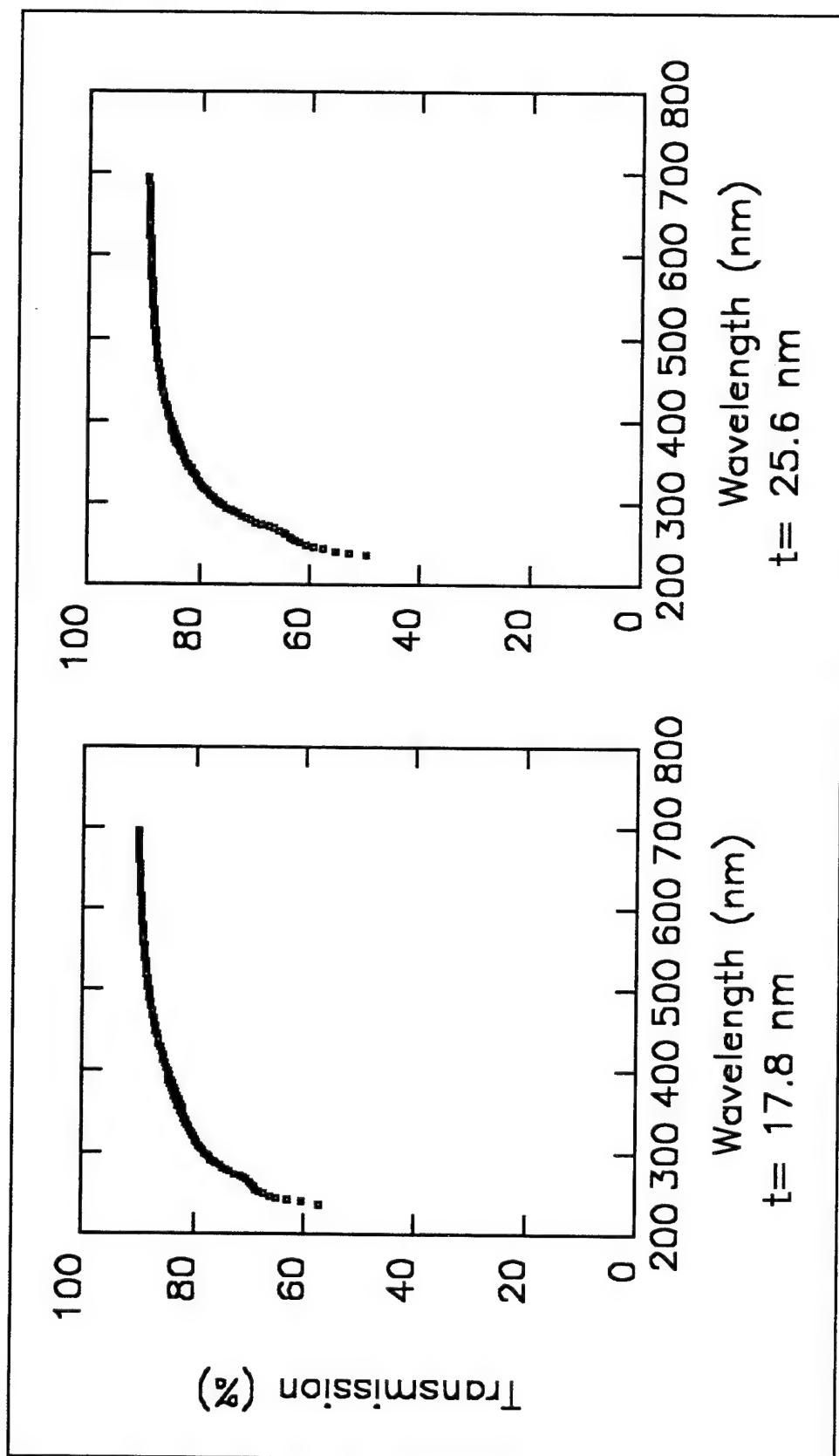


Figure B4 Transmission spectra measured during photodeposition of tetramethyltetraphenyltrisiloxane, DC704.

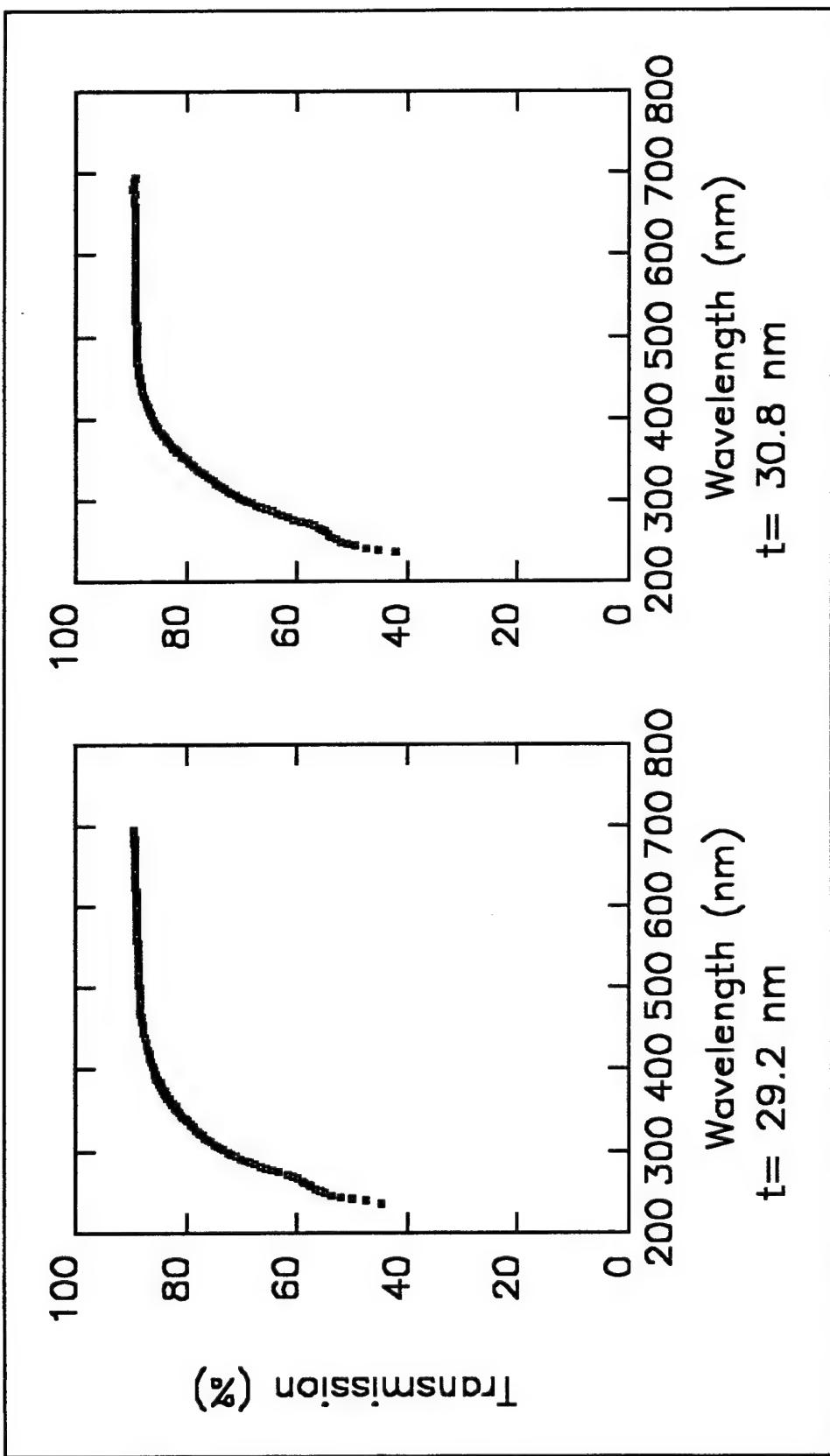


Figure B5 Transmission spectra measured during photodeposition of tetramethyltetraphenyltrisiloxane, DC704.

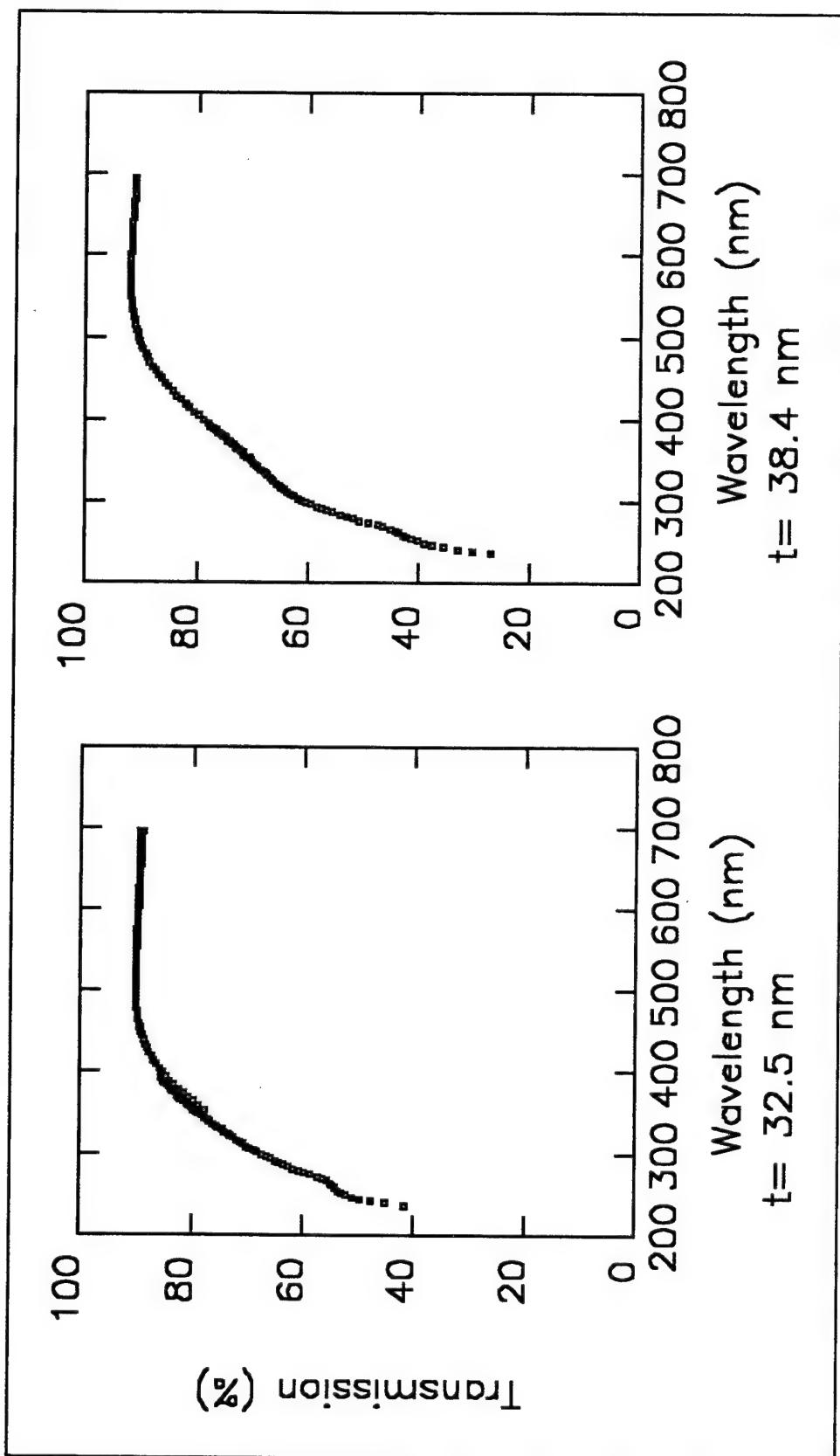


Figure B6 Transmission spectra measured during photodeposition of tetramethyltetraphenyltrisiloxane, DC704.

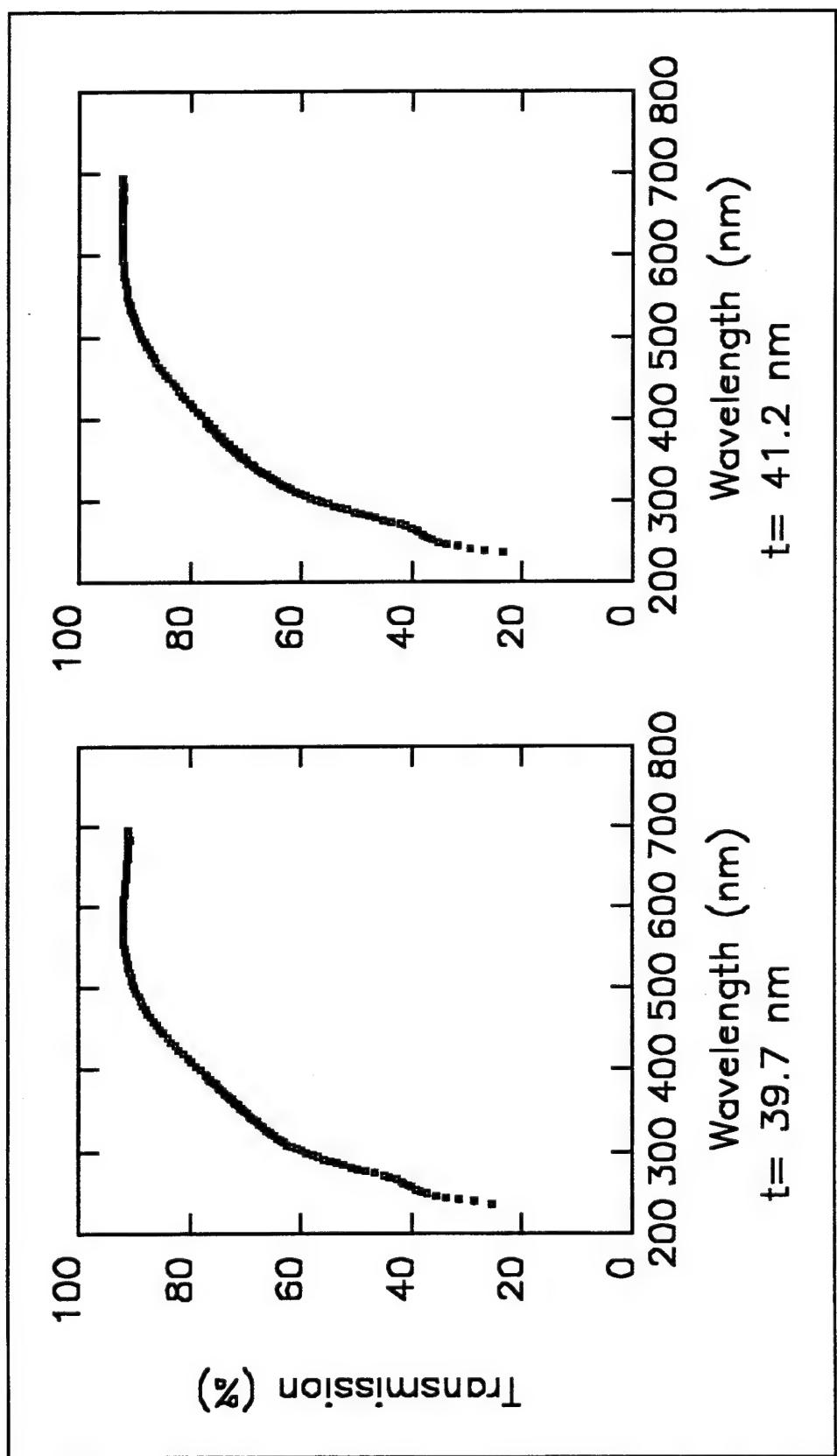


Figure B7 Transmission spectra measured during photodeposition of tetramethyltetraphenyltrisiloxane, DC704.

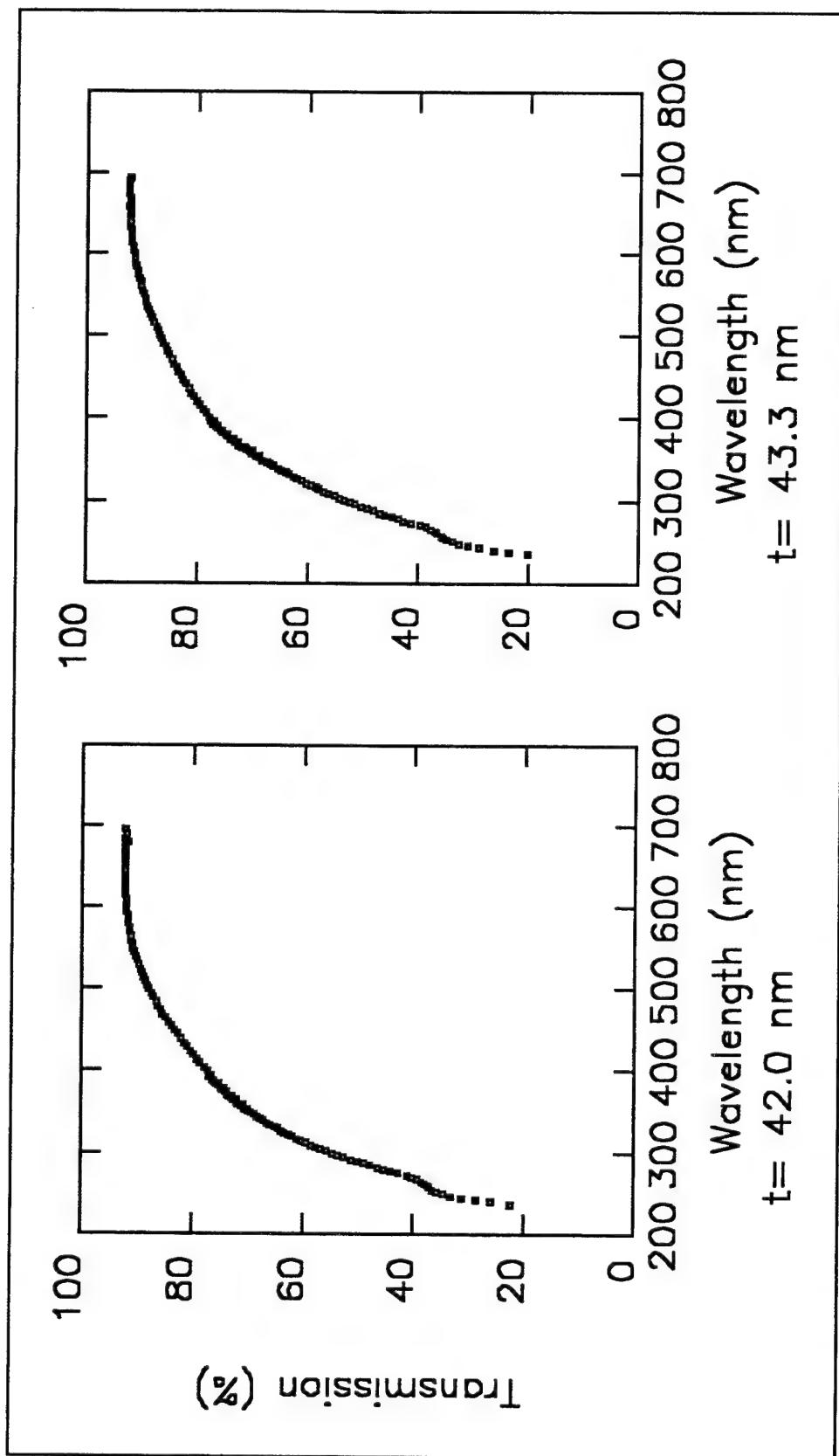


Figure B8 Transmission spectra measured during photodeposition of tetramethyltetraphenyltrisiloxane, DC704.

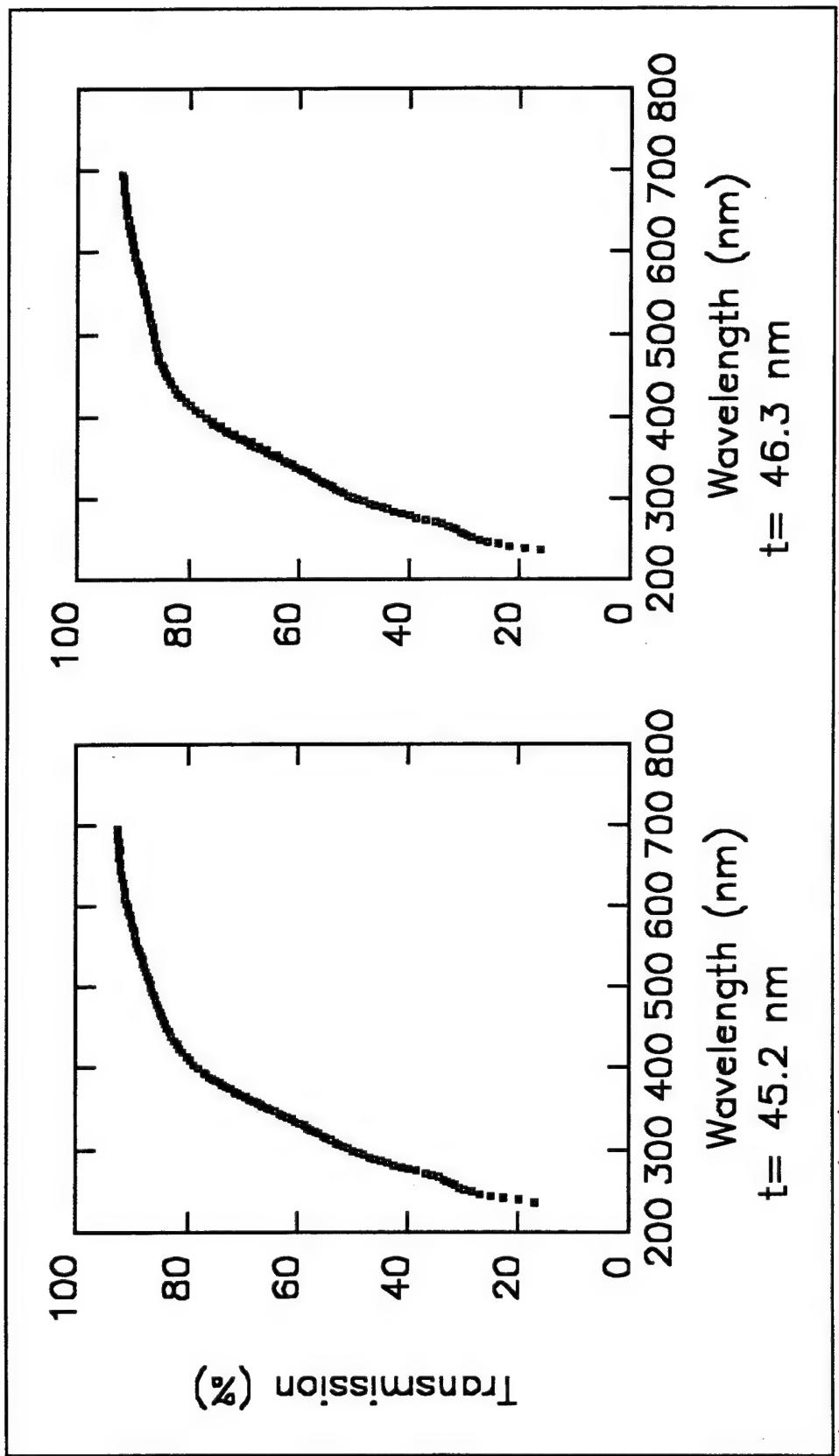


Figure B9 Transmission spectra measured during photodeposition of tetramethyltetraphenyltrisiloxane, DC704.

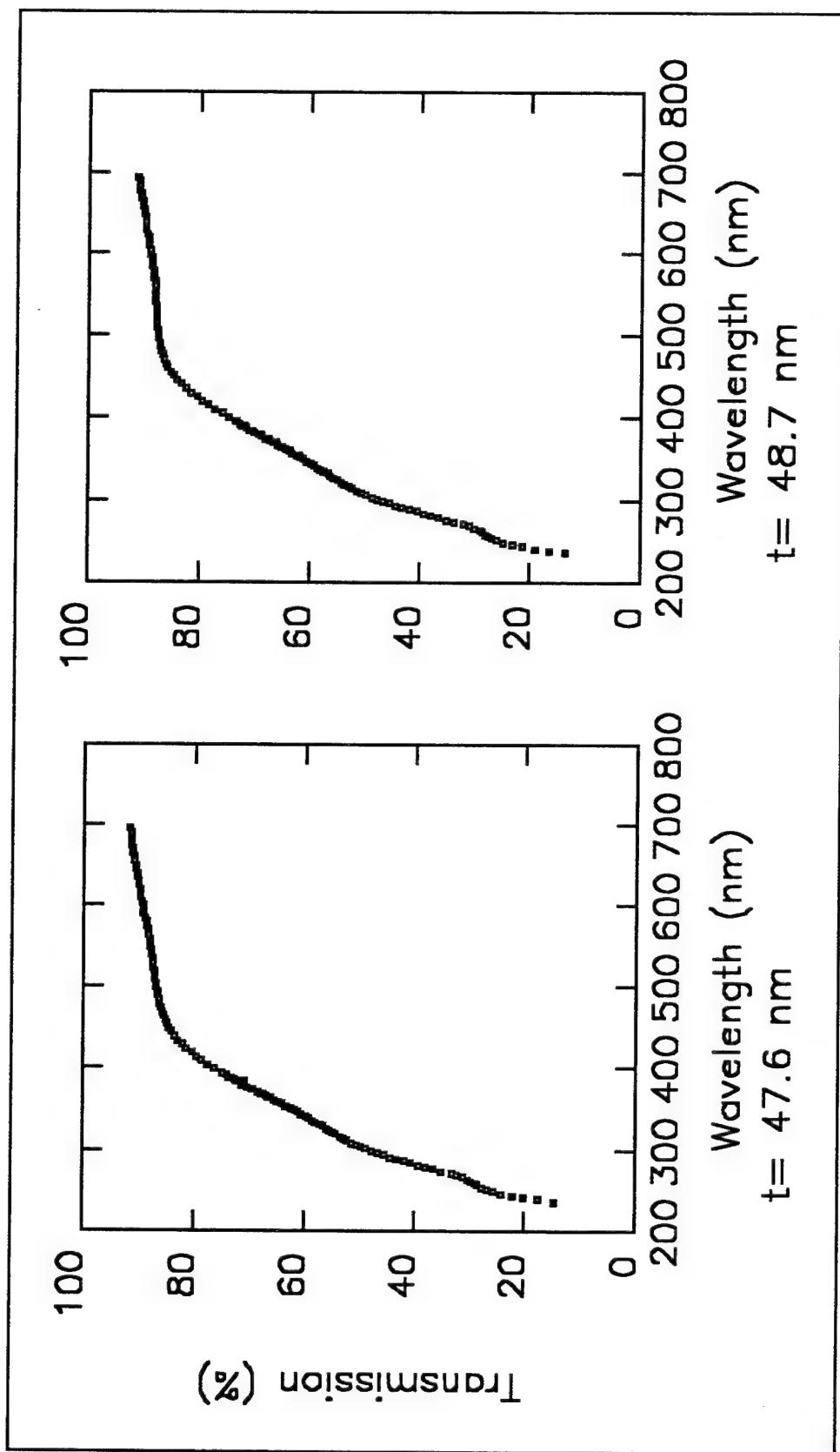


Figure B10 Transmission spectra measured during photodeposition of tetramethyltetraphenyltrisiloxane, DC704.

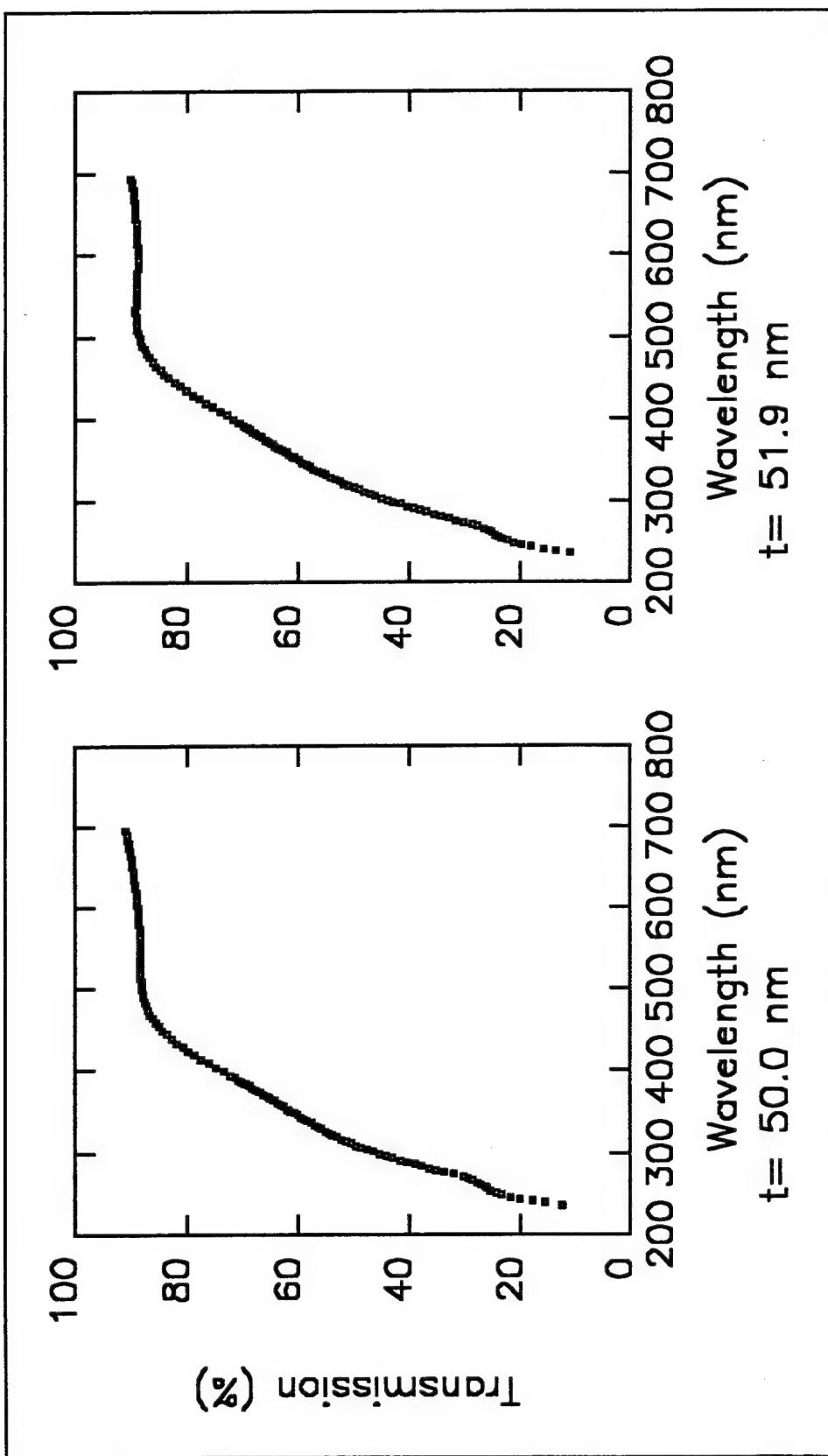


Figure B11 Transmission spectra measured during photodeposition of tetramethyltetraphenyltrisiloxane, DC704.

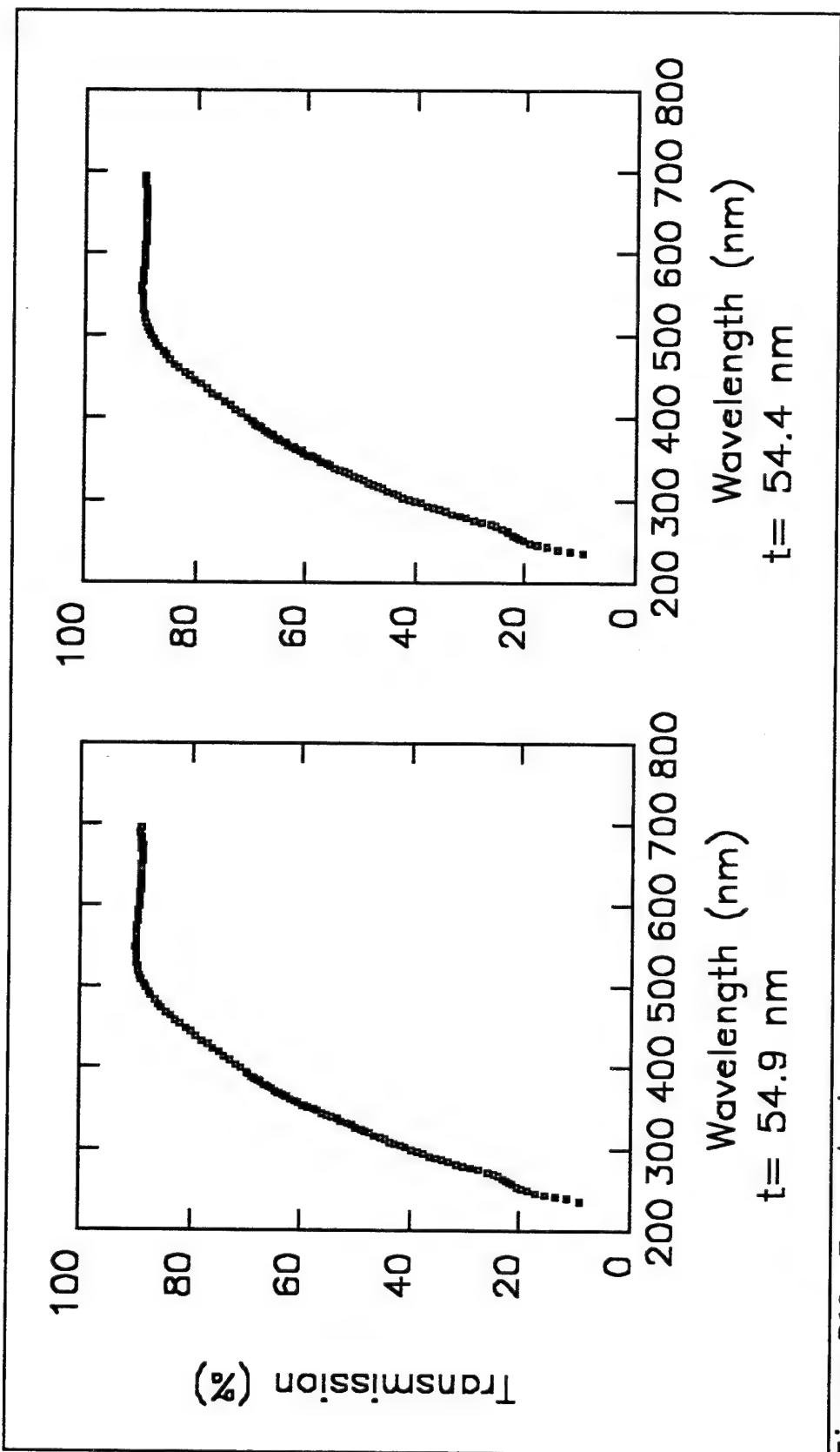


Figure B12 Transmission spectra measured during photodeposition of tetramethyltetraphenyltrisiloxane, DC704.

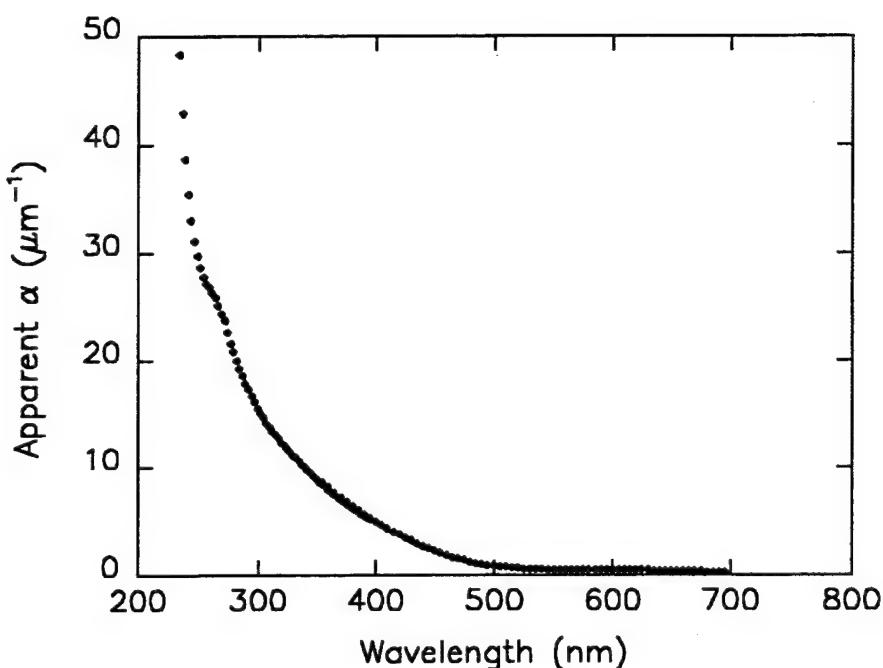


Figure B13. Apparent absorption coefficient obtained from the fits to the Beer-Lambert absorption law. Linear plot

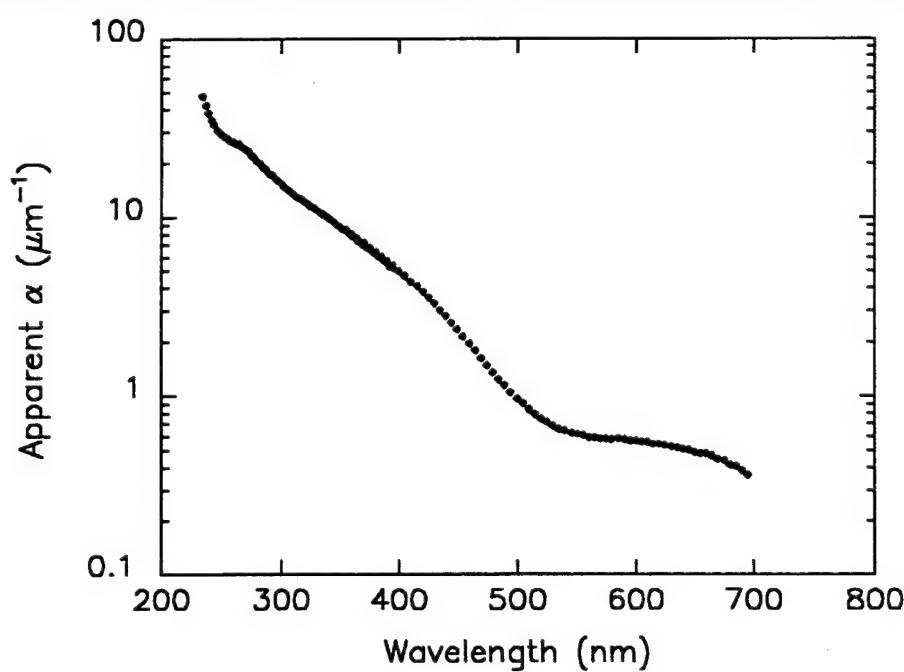


Figure B14. Apparent absorption coefficient obtained from the data fits to the Beer-Lambert absorption law. Log plot

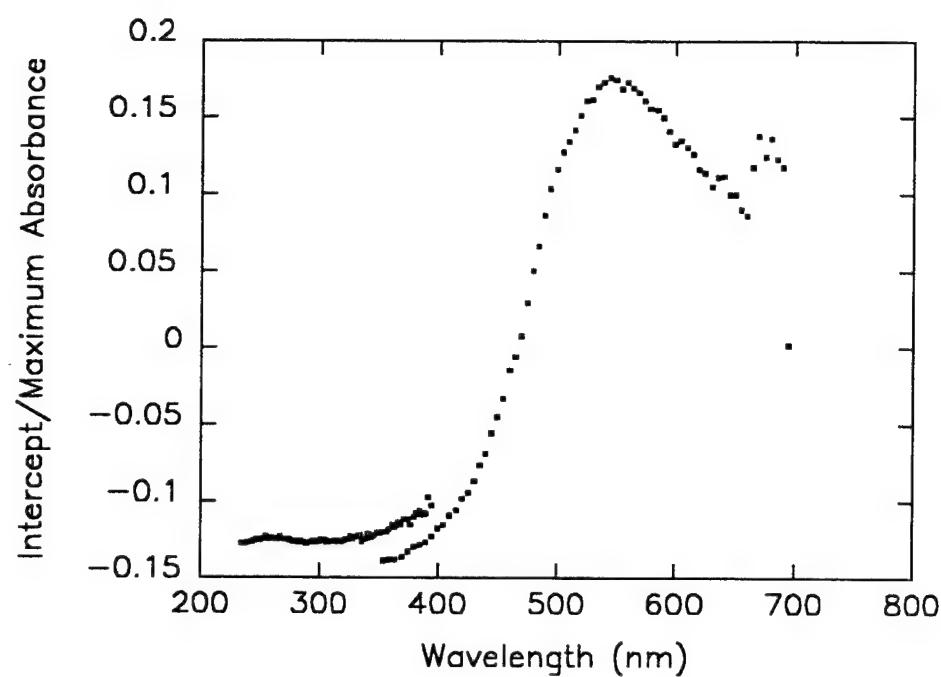


Figure B15. Plot of the ratio of the intercept of the Beer's law fit to the DC704 absorption data to the maximum value of absorbance.

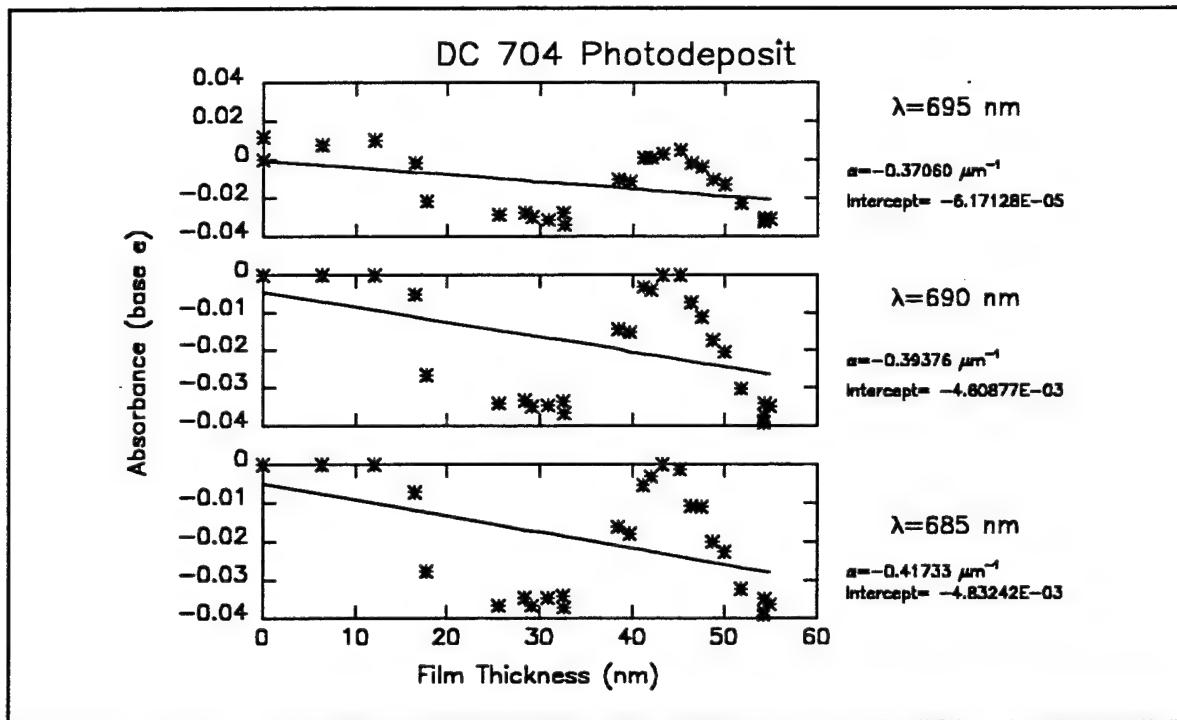


Figure B16a. Fits of measured transmission spectra to the Beer-Lambert absorption law. (Visible wavelength range)

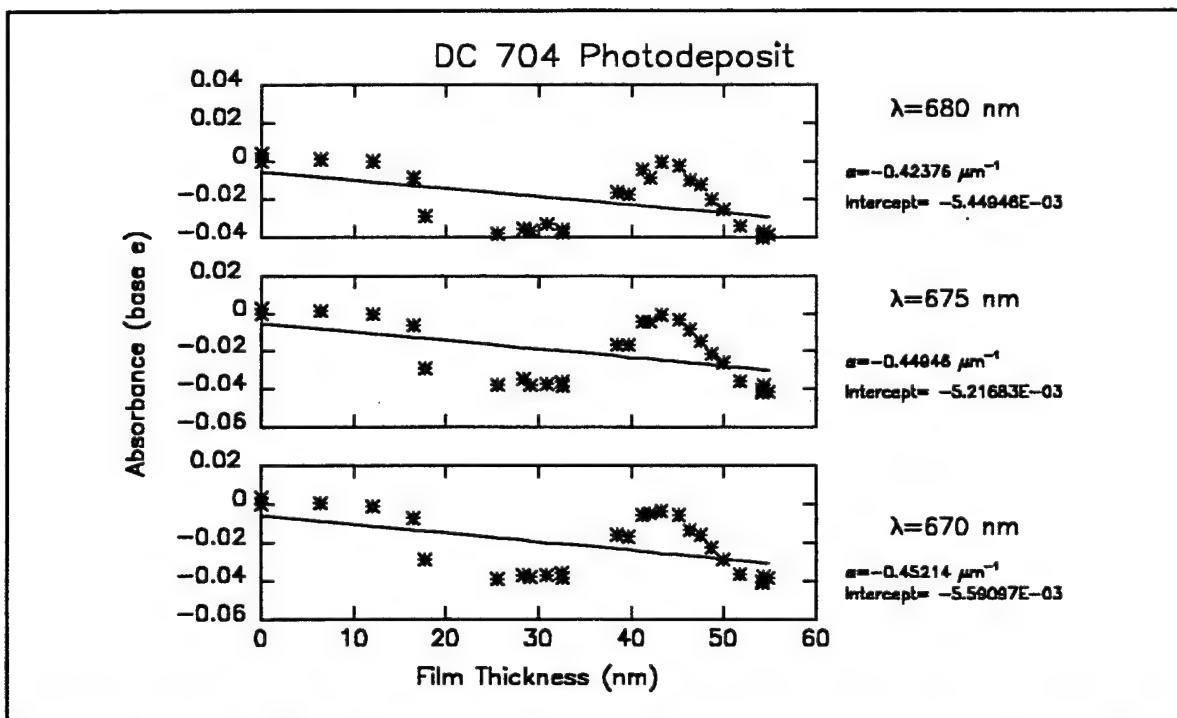


Figure B16b. Fits of measured transmission spectra to the Beer-Lambert absorption law. (Visible wavelength range)

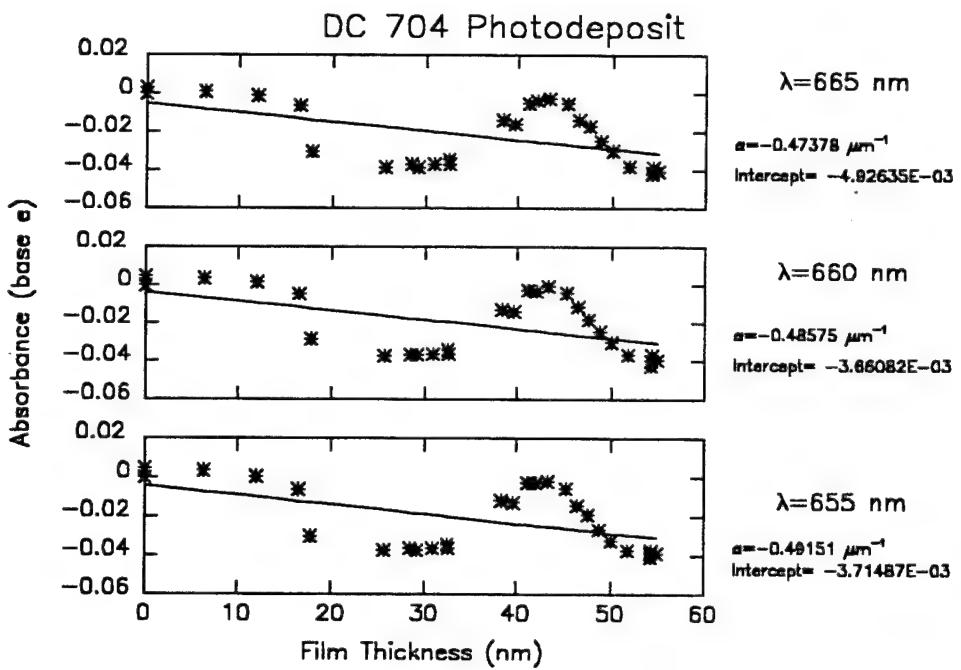


Figure B16c. Fits of measured transmission spectra to the Beer-Lambert absorption law. (Visible wavelength range)

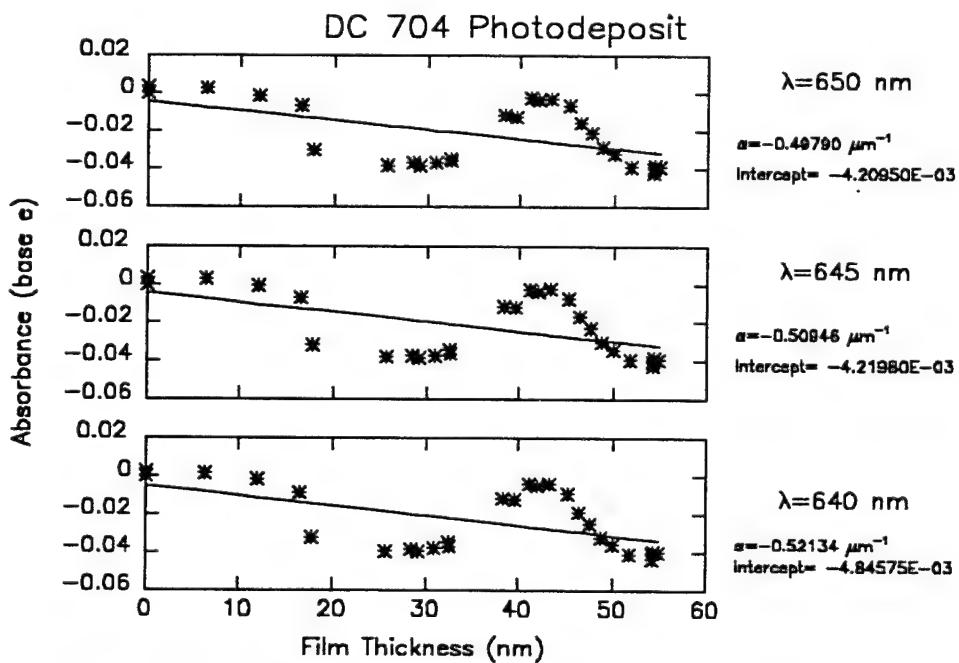


Figure B16d. Fits of measured transmission spectra to the Beer-Lambert absorption law. (Visible wavelength range)

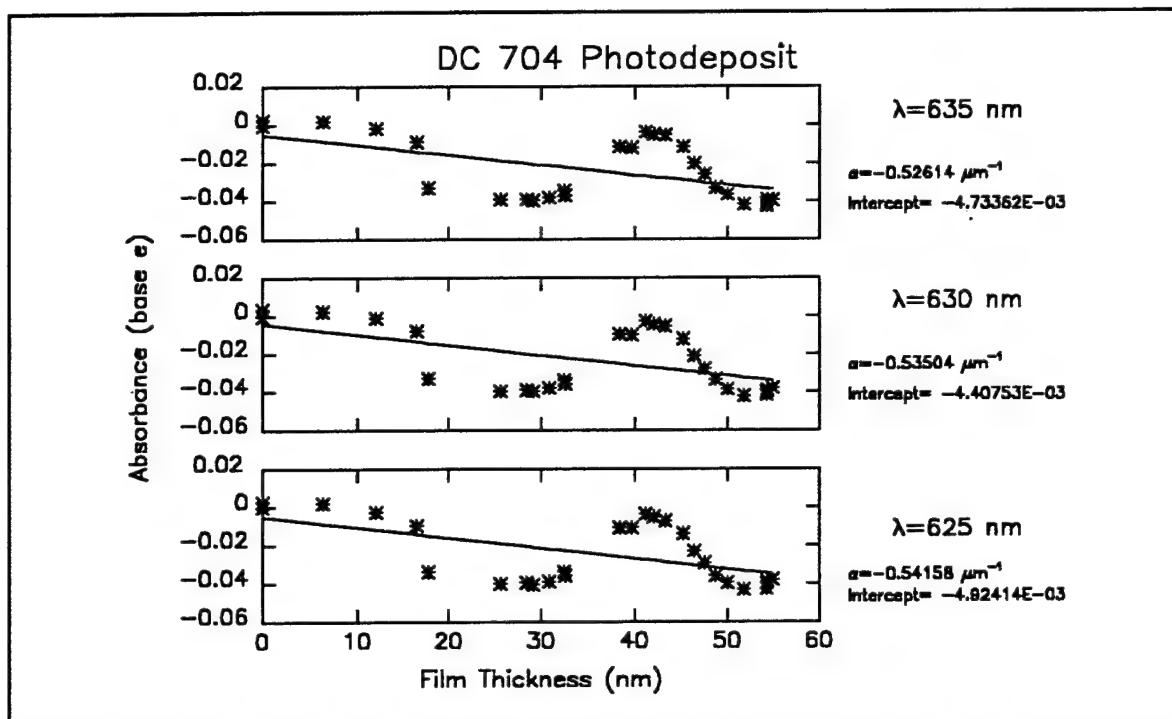


Figure B16e. Fits of measured transmission spectra to the Beer-Lambert absorption law. (Visible wavelength range)

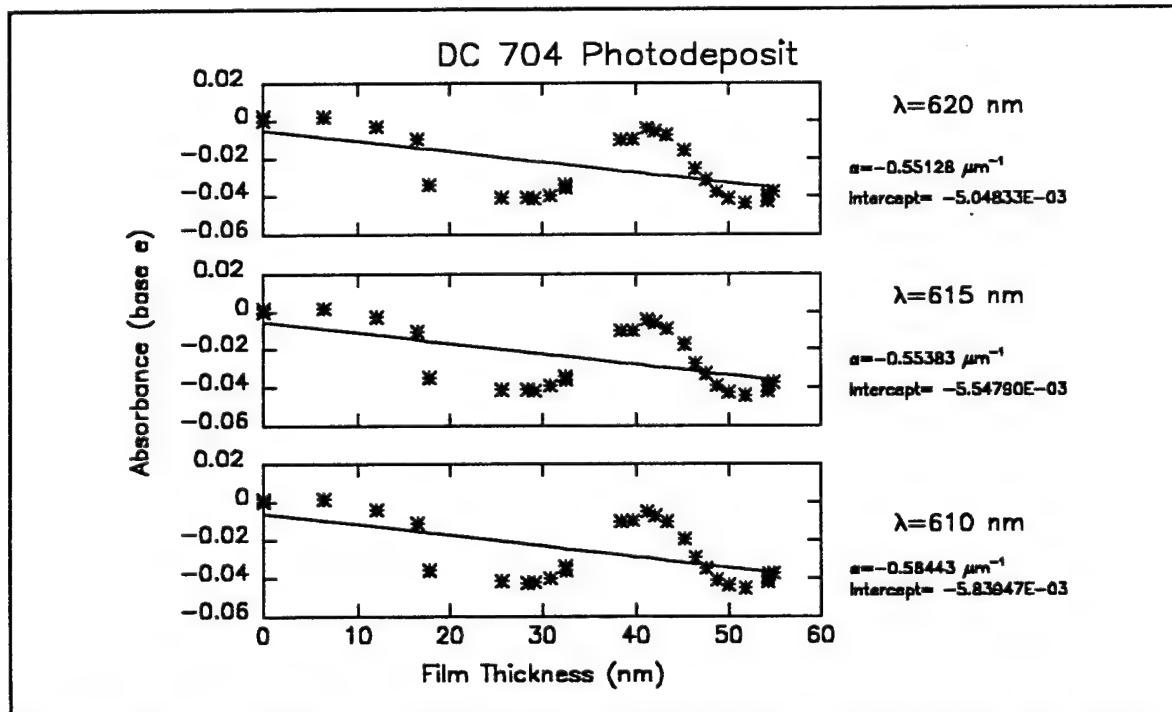


Figure B16f. Fits of measured transmission spectra to the Beer-Lambert absorption law. (Visible wavelength range)

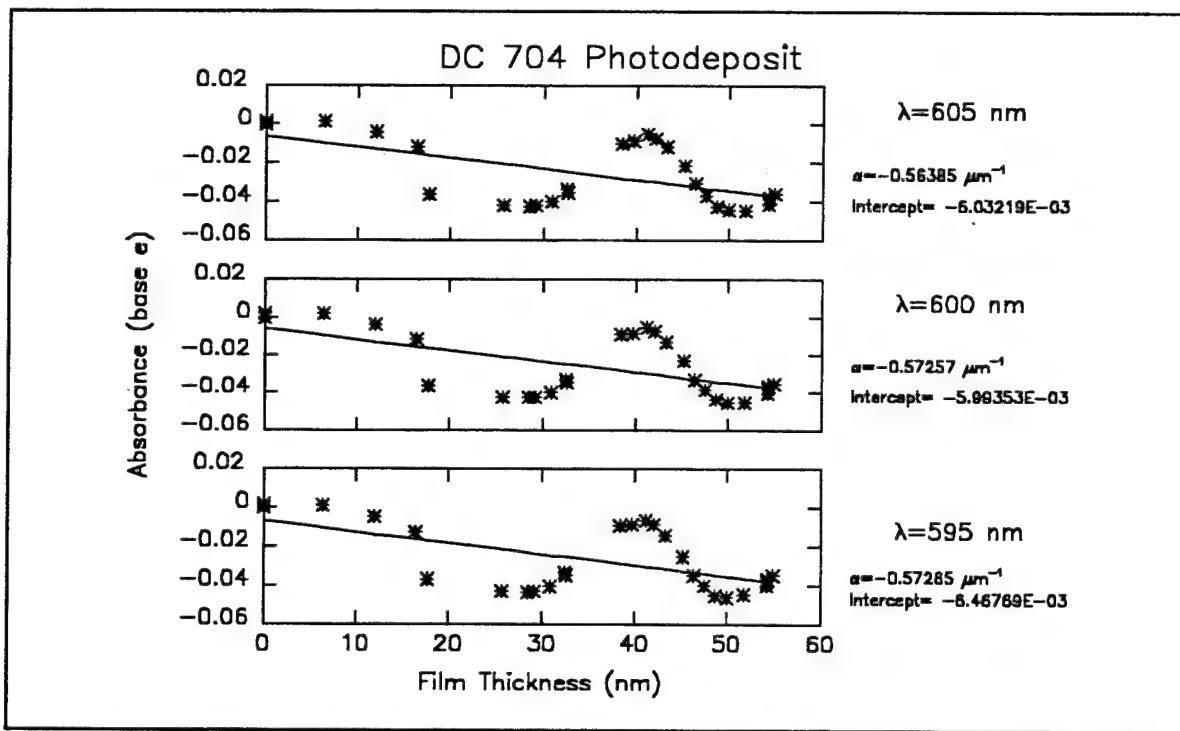


Figure B16g. Fits of measured transmission spectra to the Beer-Lambert absorption law. (Visible wavelength range)

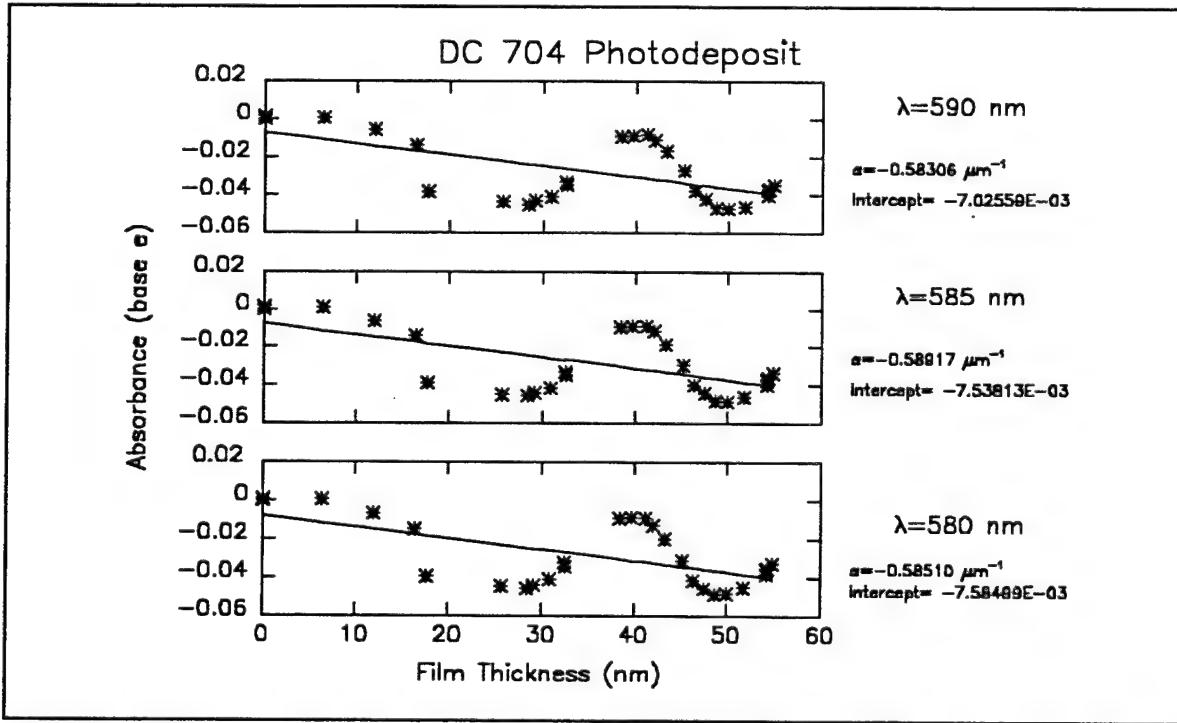


Figure B16h. Fits of measured transmission spectra to the Beer-Lambert absorption law. (Visible wavelength range)

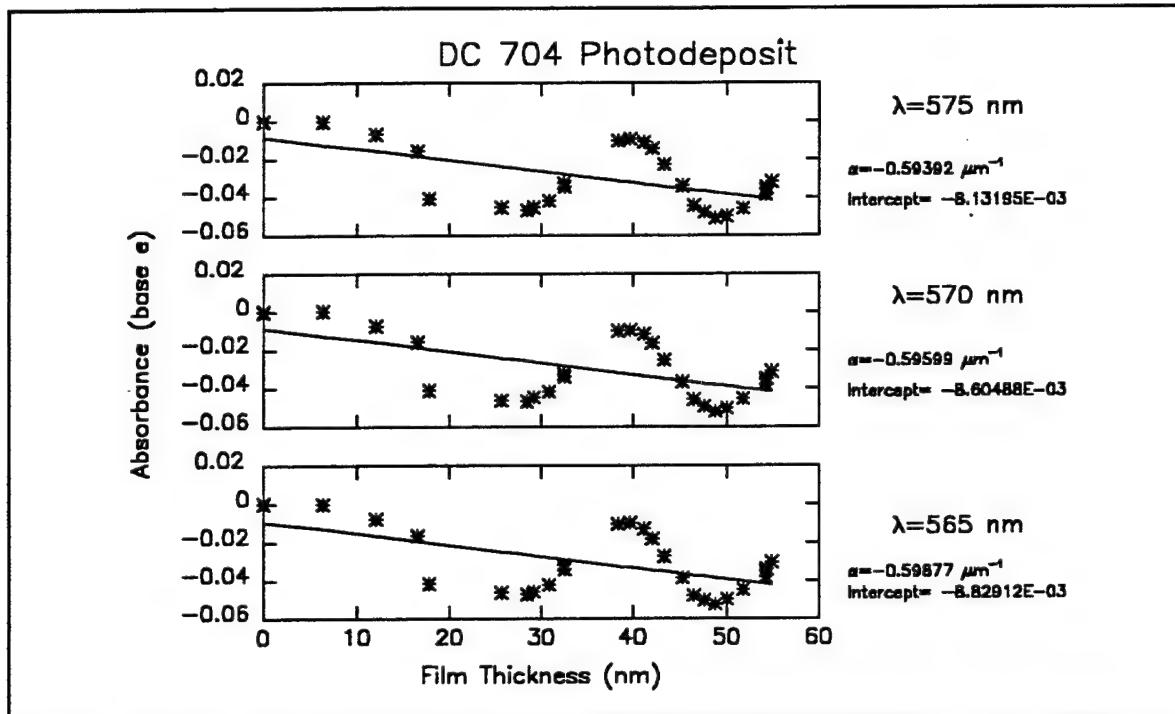


Figure B16i. Fits of measured transmission spectra to the Beer-Lambert absorption law. (Visible wavelength range)

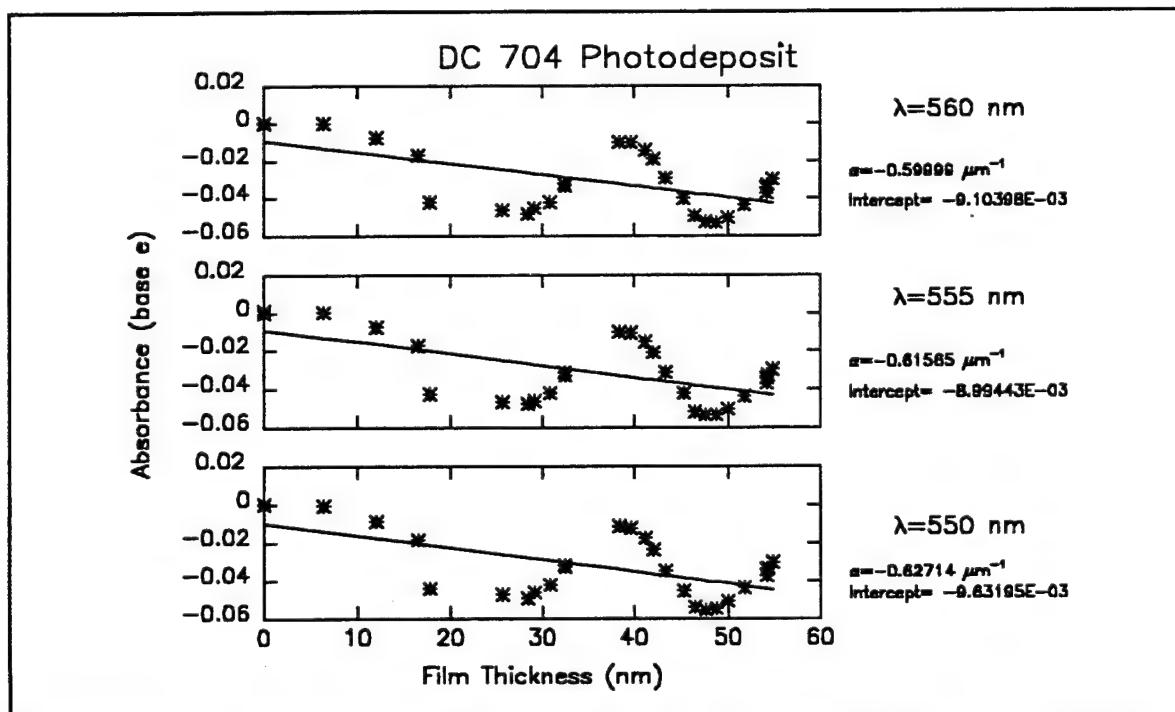


Figure B16j. Fits of measured transmission spectra to the Beer-Lambert absorption law. (Visible wavelength range)

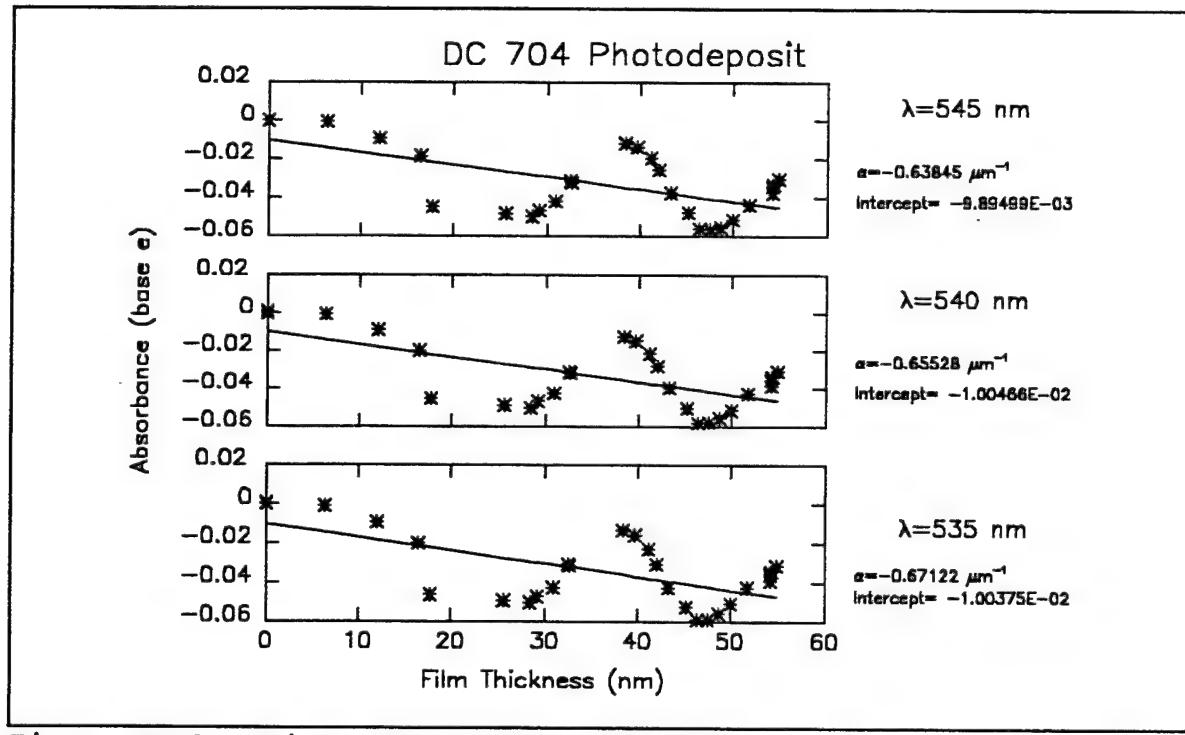


Figure B16k. Fits of measured transmission spectra to the Beer-Lambert absorption law. (Visible wavelength range)

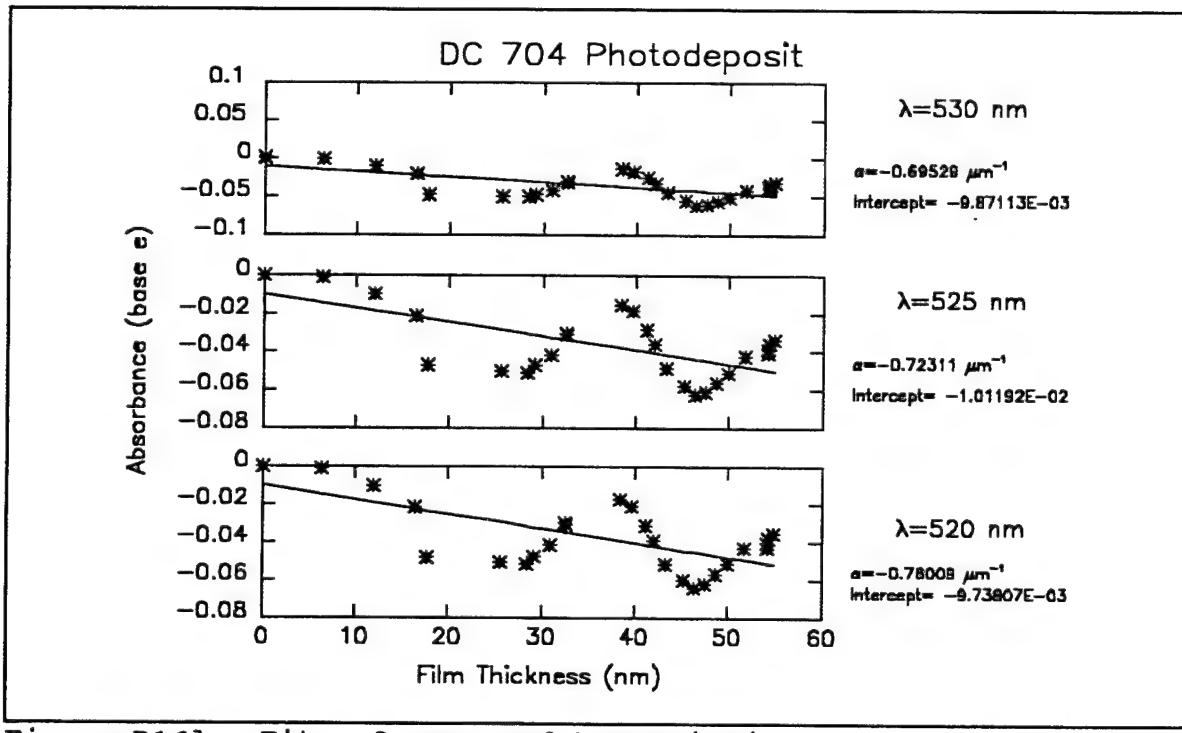


Figure B16l. Fits of measured transmission spectra to the Beer-Lambert absorption law. (Visible wavelength range)

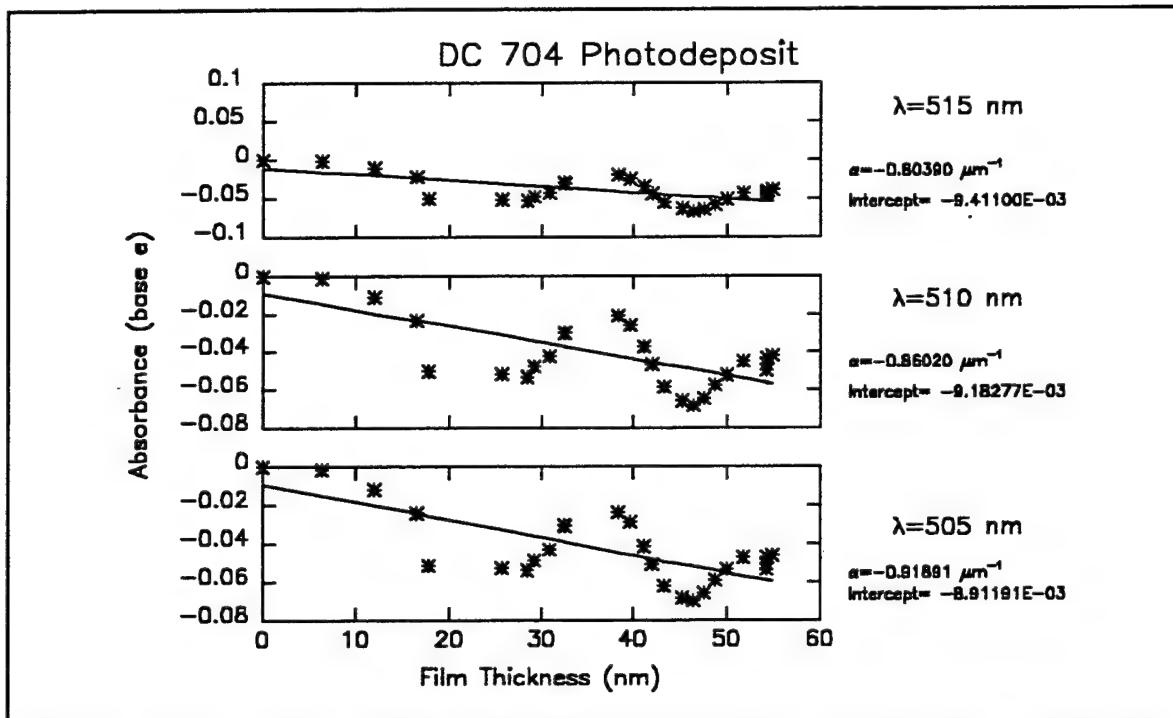


Figure B16m. Fits of measured transmission spectra to the Beer-Lambert absorption law. (Visible wavelength range)

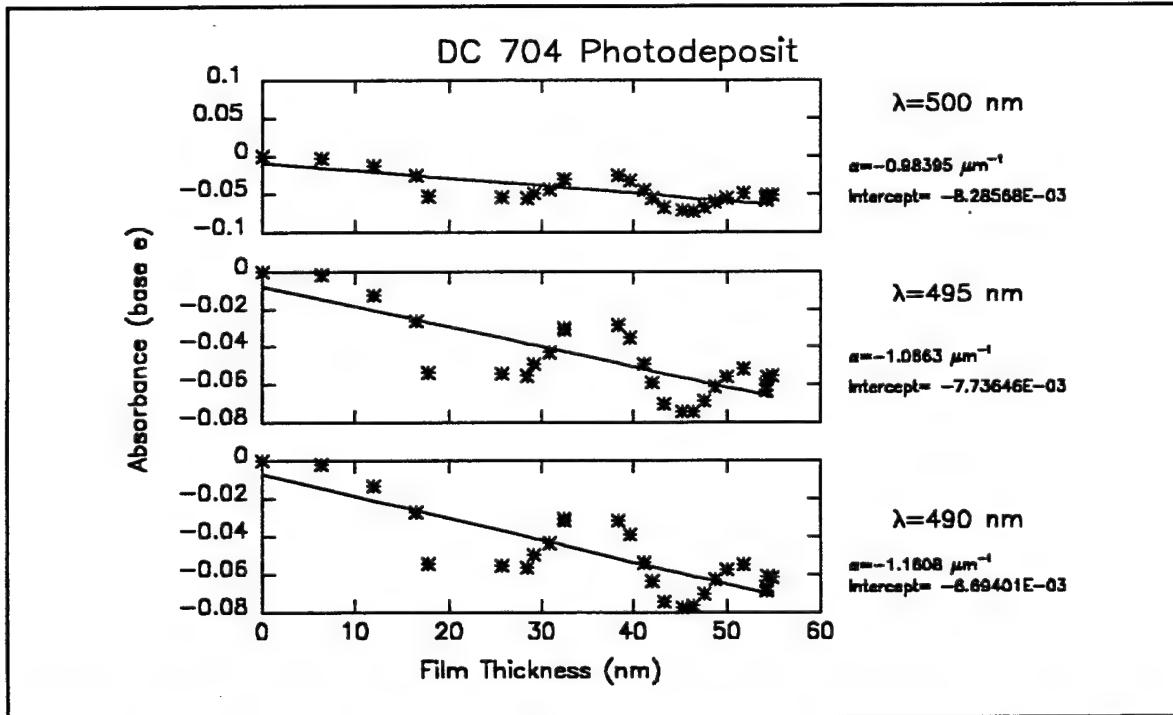


Figure B16n. Fits of measured transmission spectra to the Beer-Lambert absorption law. (Visible wavelength range)

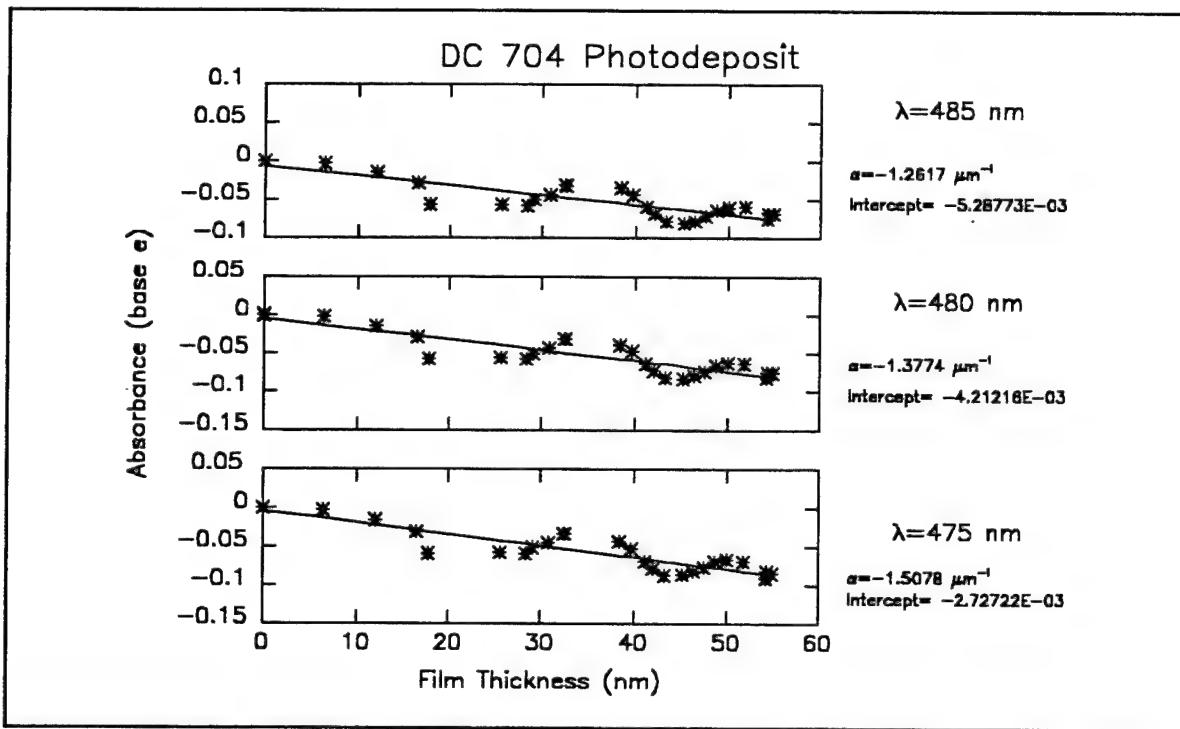


Figure B16o. Fits of measured transmission spectra to the Beer-Lambert absorption law. (Visible wavelength range)

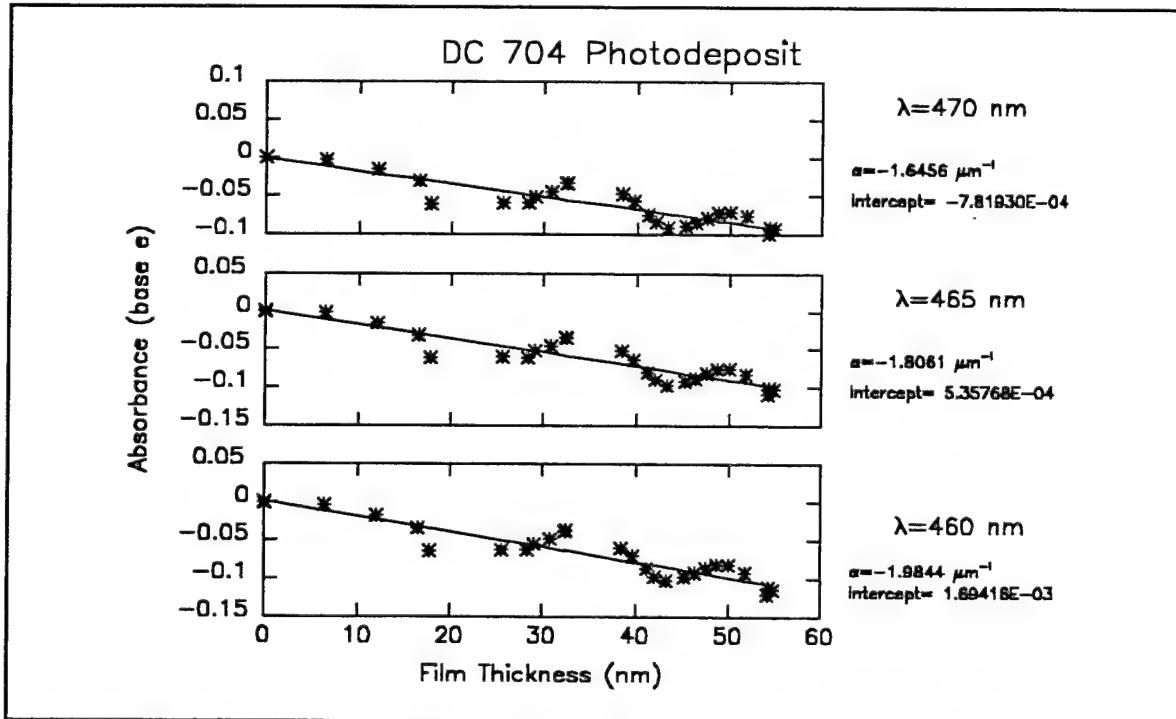


Figure B16p. Fits of measured transmission spectra to the Beer-Lambert absorption law. (Visible wavelength range)

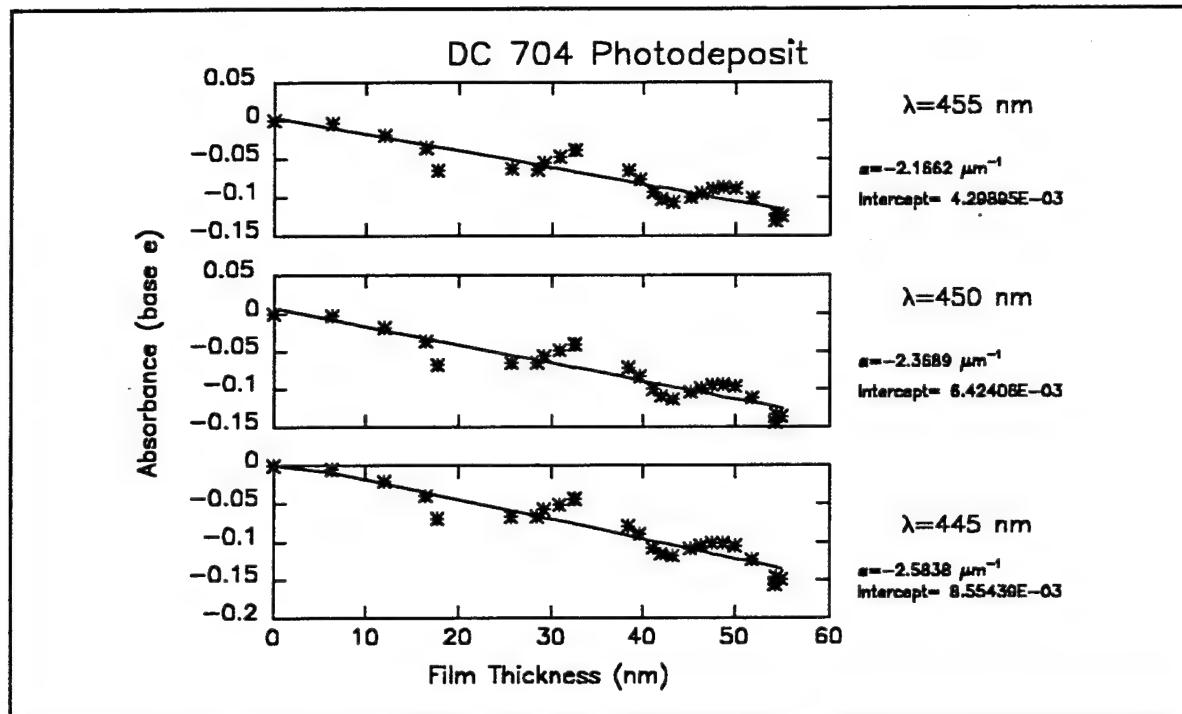


Figure B16q. Fits of measured transmission spectra to the Beer-Lambert absorption law. (Visible wavelength range)

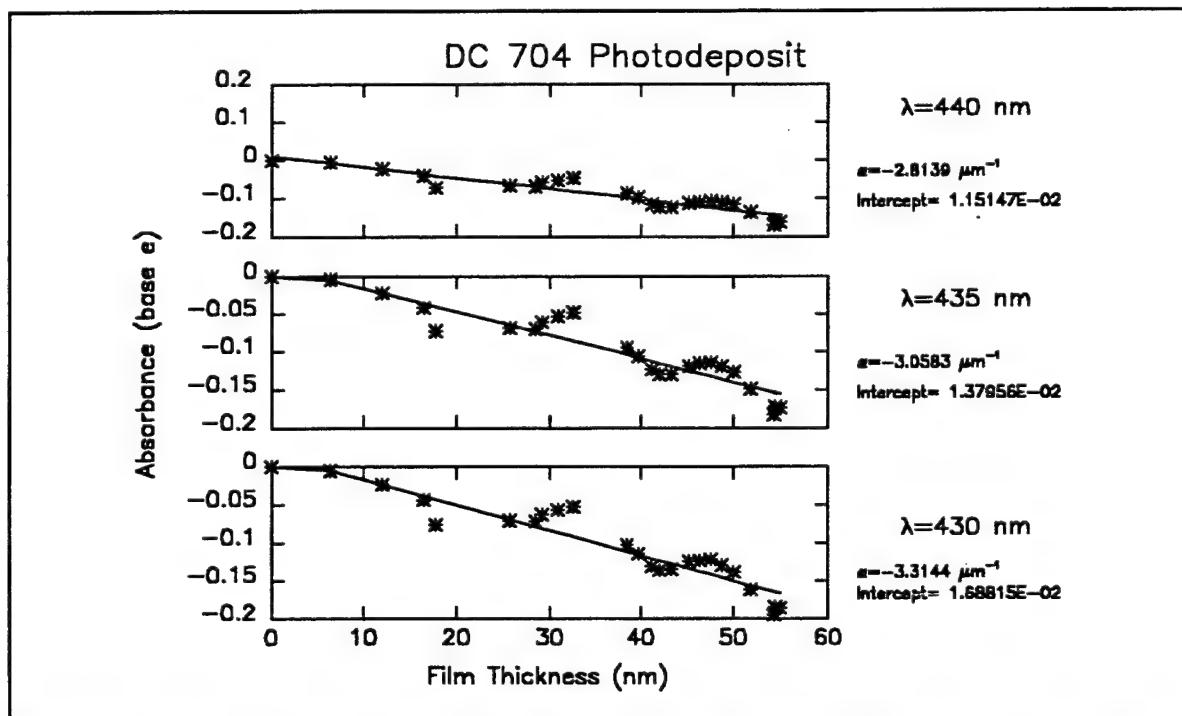


Figure B16r. Fits of measured transmission spectra to the Beer-Lambert absorption law. (Visible wavelength range)

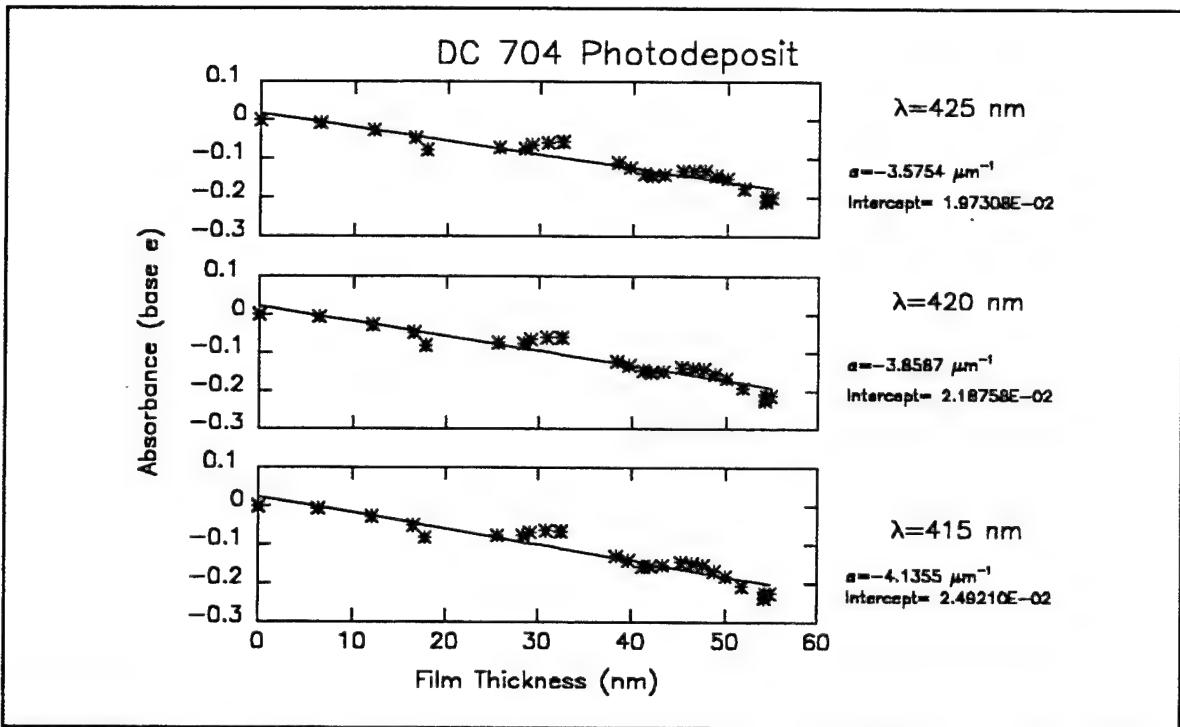


Figure B16s. Fits of measured transmission spectra to the Beer-Lambert absorption law. (Visible wavelength range)

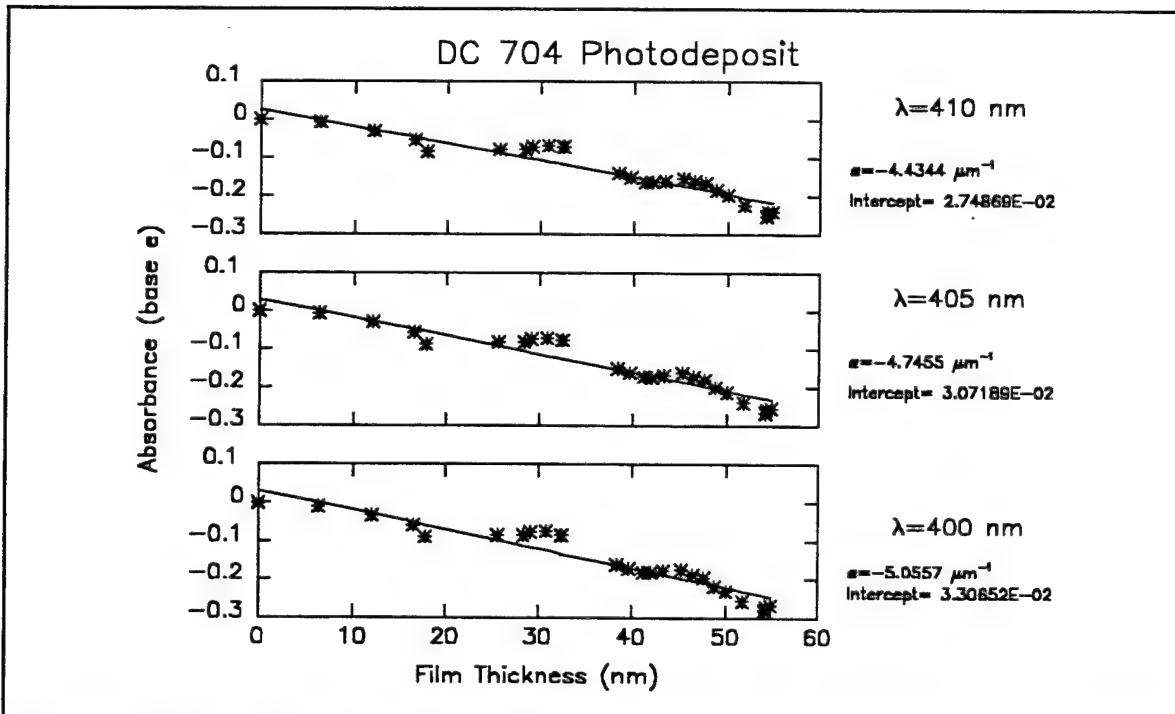


Figure B16t. Fits of measured transmission spectra to the Beer-Lambert absorption law. (Visible wavelength range)

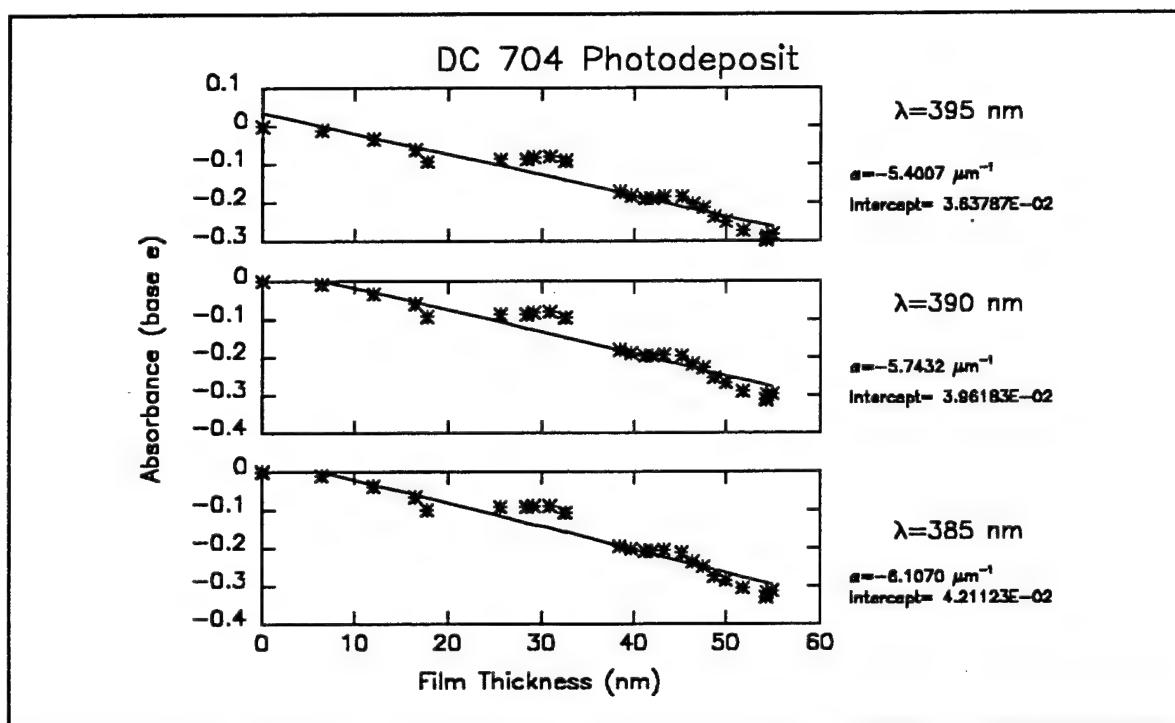


Figure B16u. Fits of measured transmission spectra to the Beer-Lambert absorption law. (Visible wavelength range)

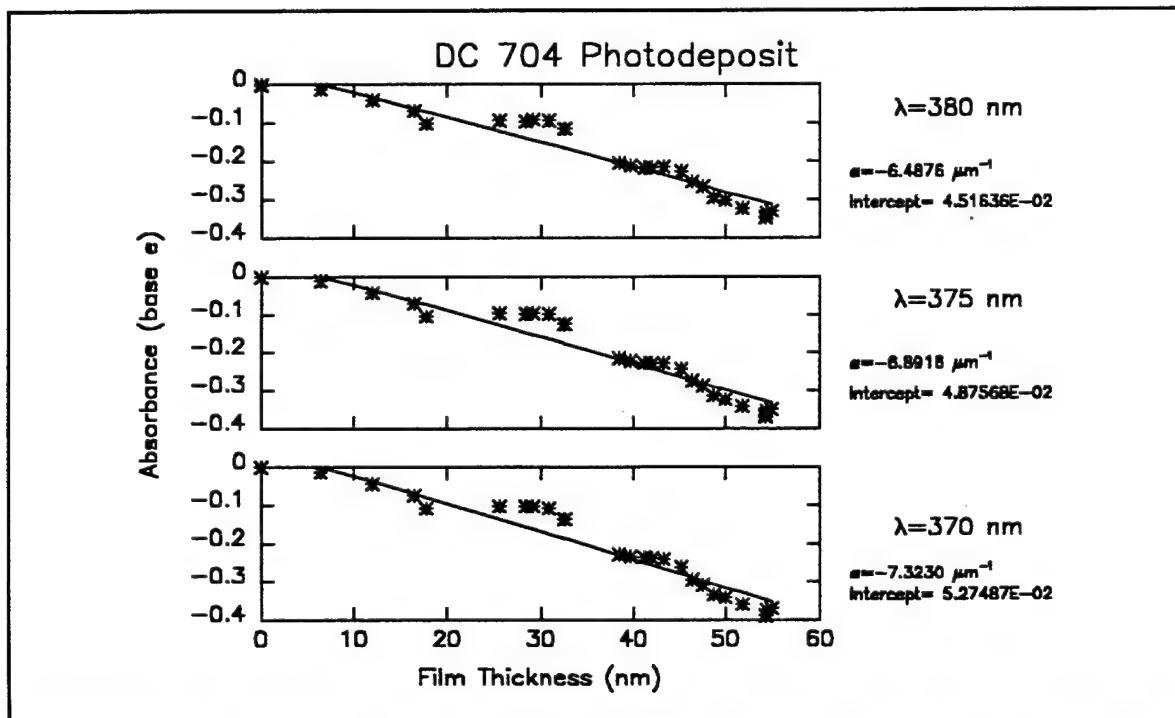


Figure B16v. Fits of measured transmission spectra to the Beer-Lambert absorption law. (Visible wavelength range)

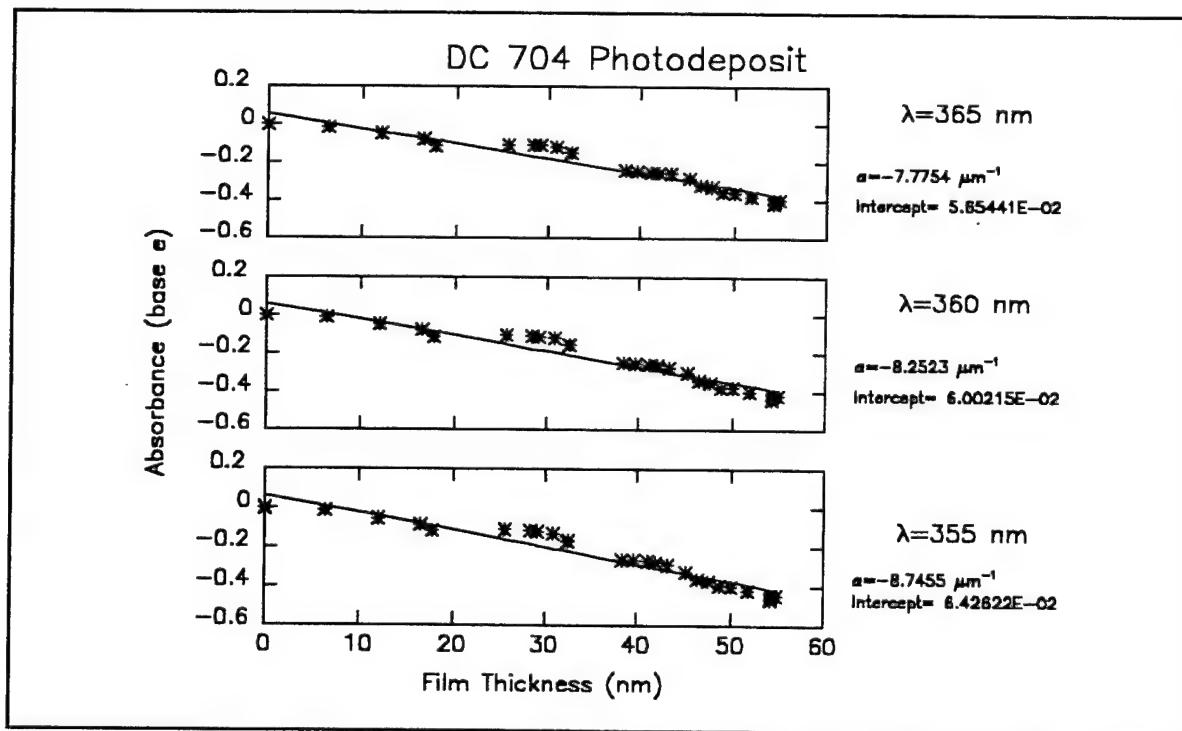


Figure B16w. Fits of measured transmission spectra to the Beer-Lambert absorption law. (Visible wavelength range)

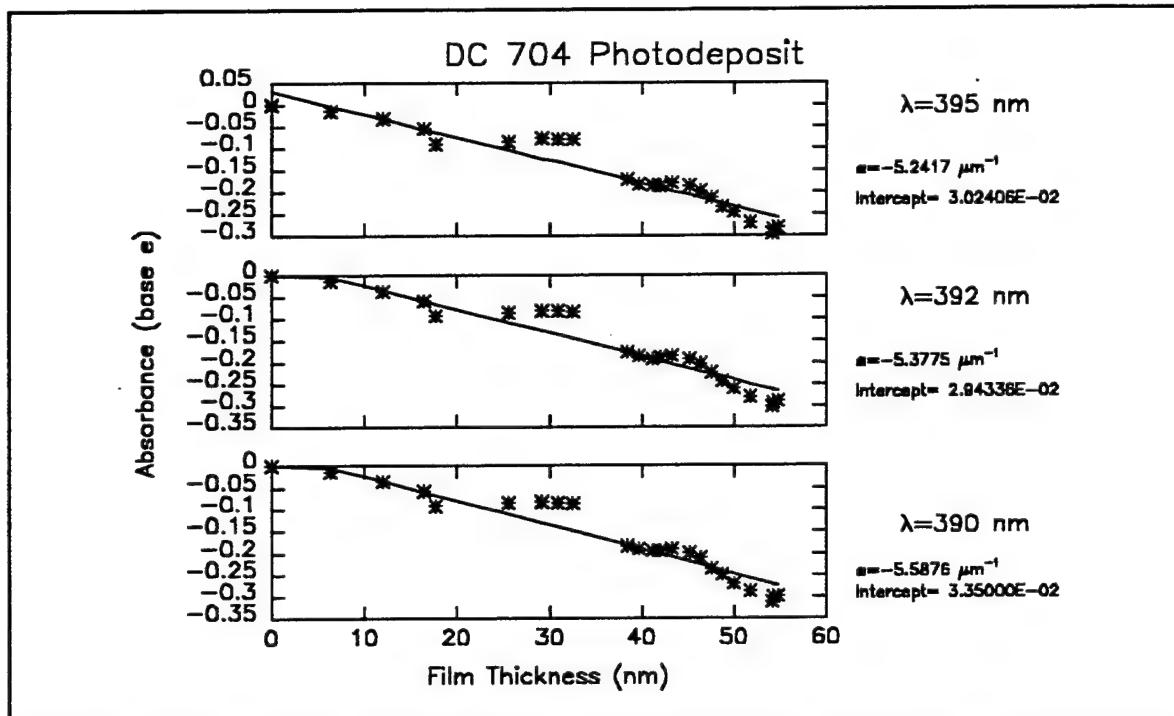


Figure B17a. Fits of measured transmission spectra to the Beer-Lambert absorption law. (Ultraviolet wavelength range)

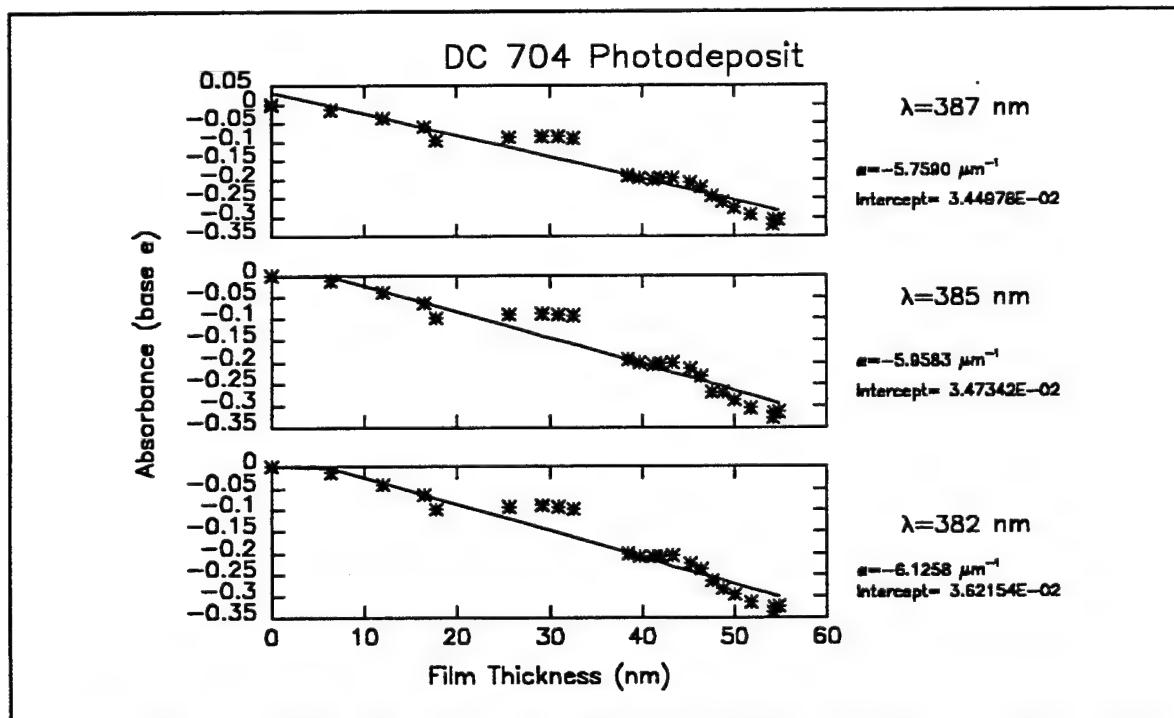


Figure B17b. Fits of measured transmission spectra to the Beer-Lambert absorption law. (Ultraviolet wavelength range)

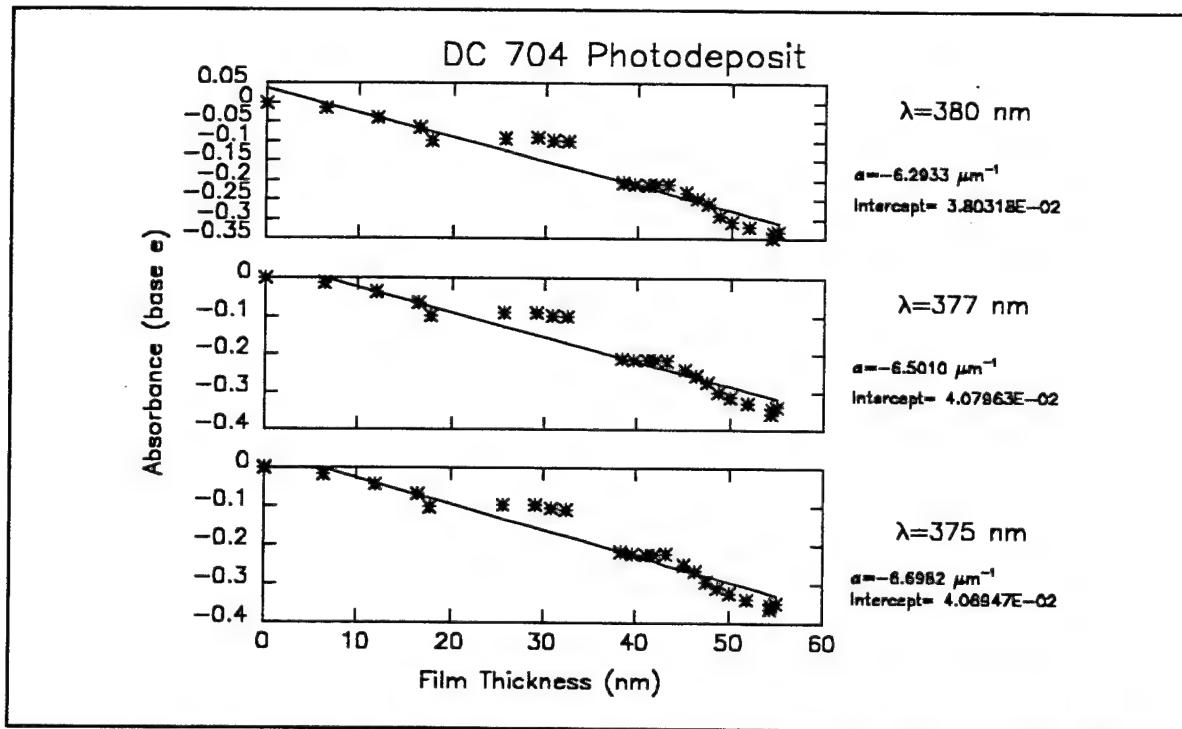


Figure B17c. Fits of measured transmission spectra to the Beer-Lambert absorption law. (Ultraviolet wavelength range)

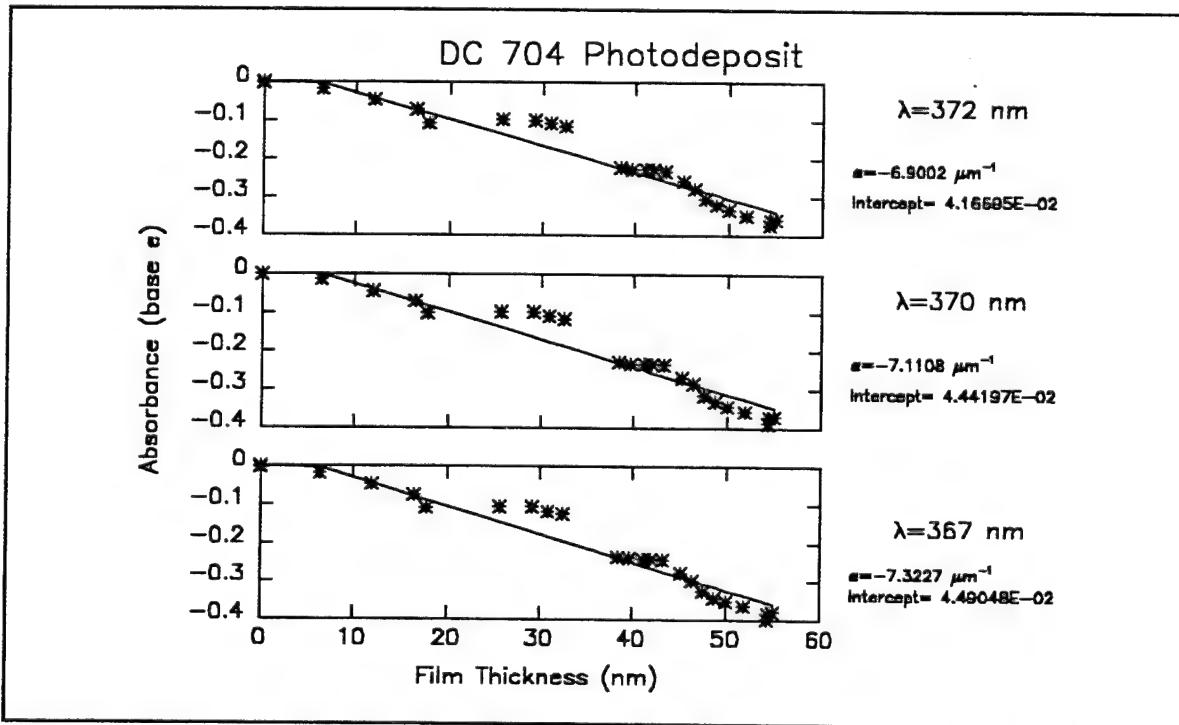


Figure B17d. Fits of measured transmission spectra to the Beer-Lambert absorption law. (Ultraviolet wavelength range)

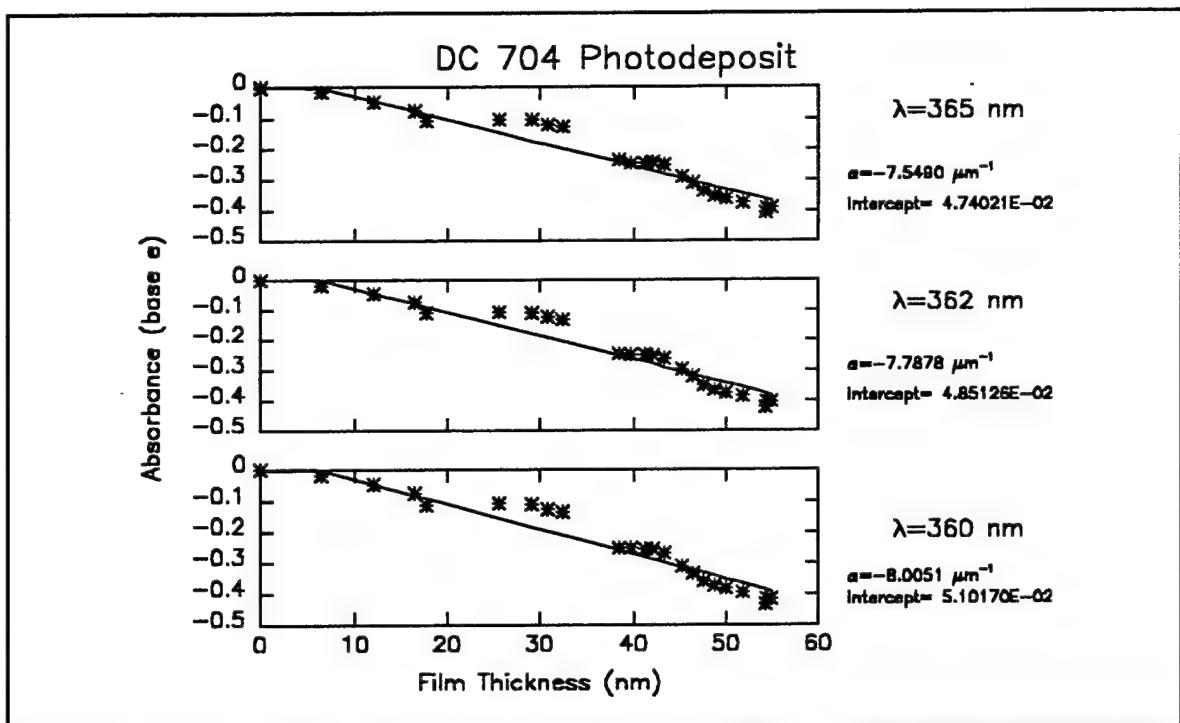


Figure B17e. Fits of measured transmission spectra to the Beer-Lambert absorption law. (Ultraviolet wavelength range)

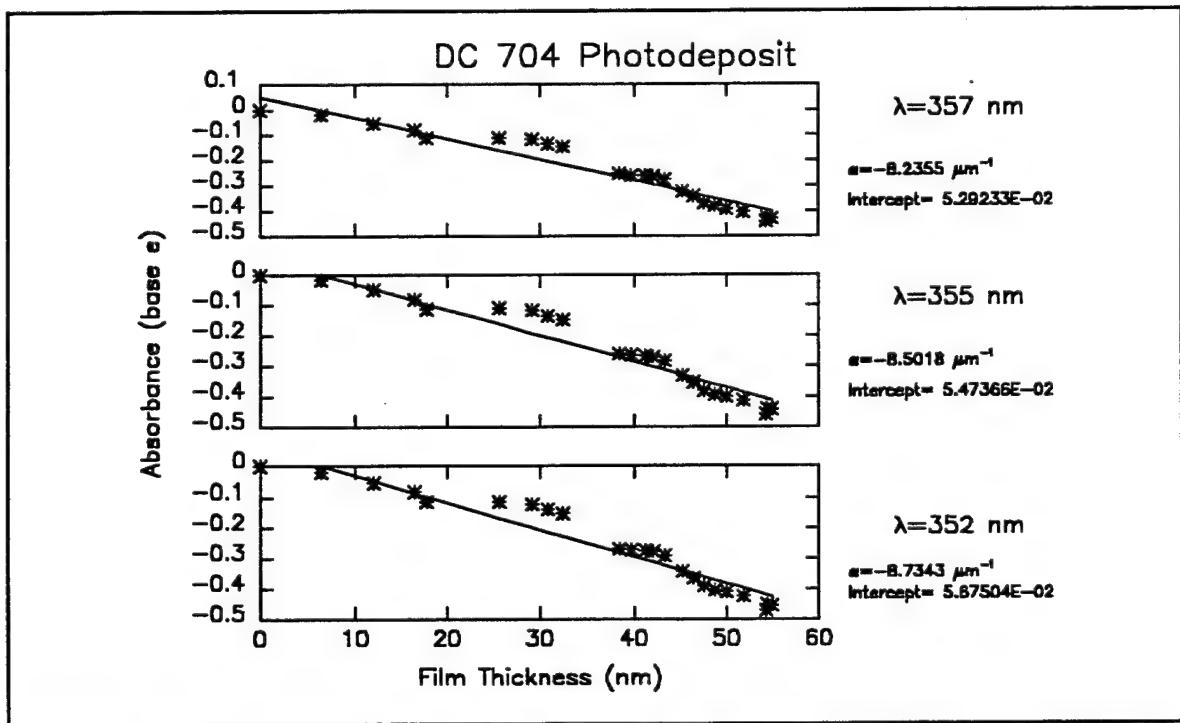


Figure B17f. Fits of measured transmission spectra to the Beer-Lambert absorption law. (Ultraviolet wavelength range)

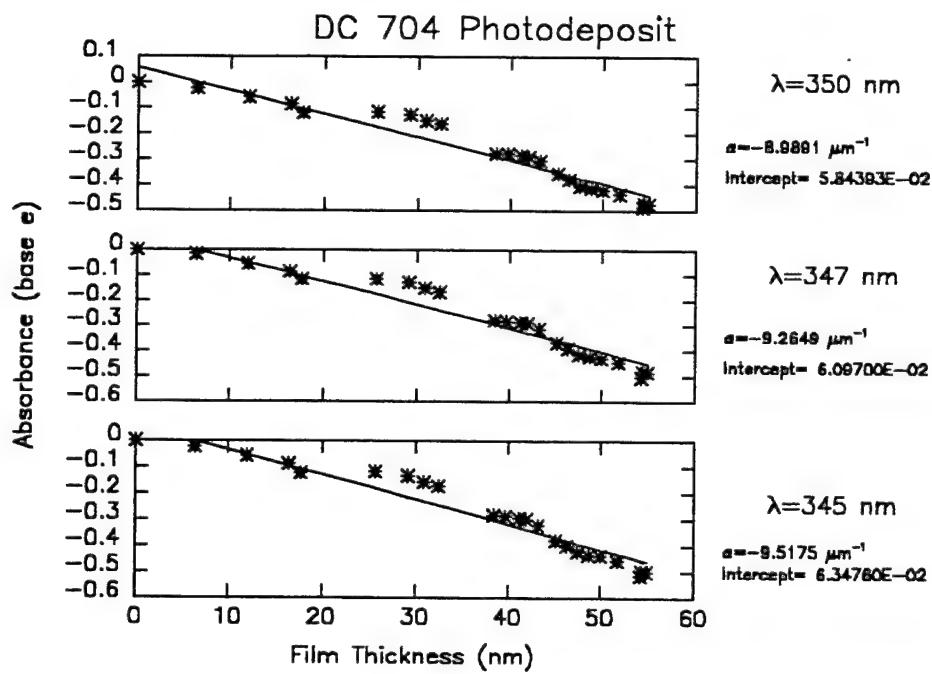


Figure B17g. Fits of measured transmission spectra to the Beer-Lambert absorption law. (Ultraviolet wavelength range)

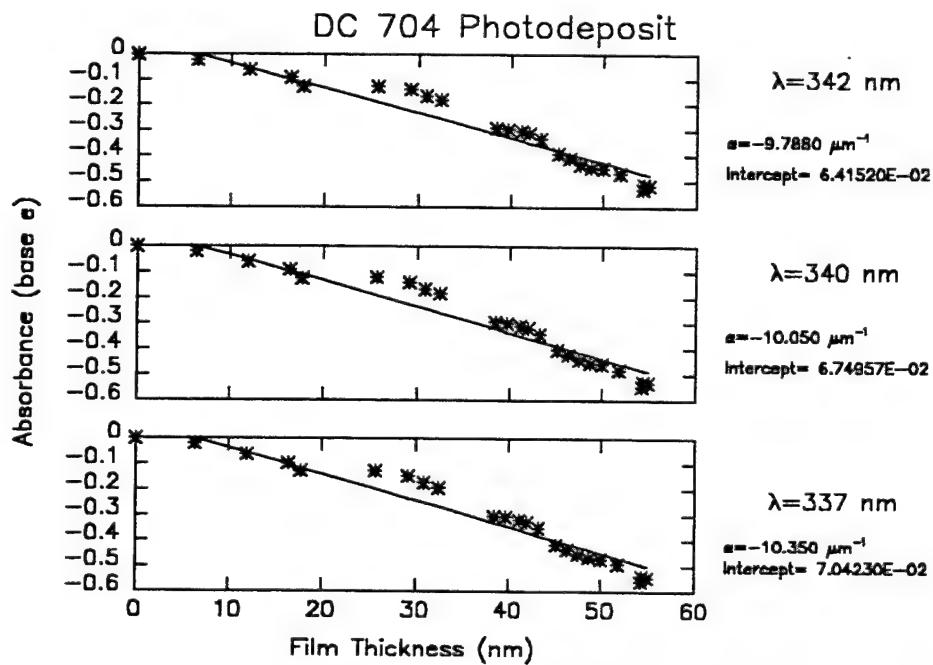


Figure B17h. Fits of measured transmission spectra to the Beer-Lambert absorption law. (Ultraviolet wavelength range)

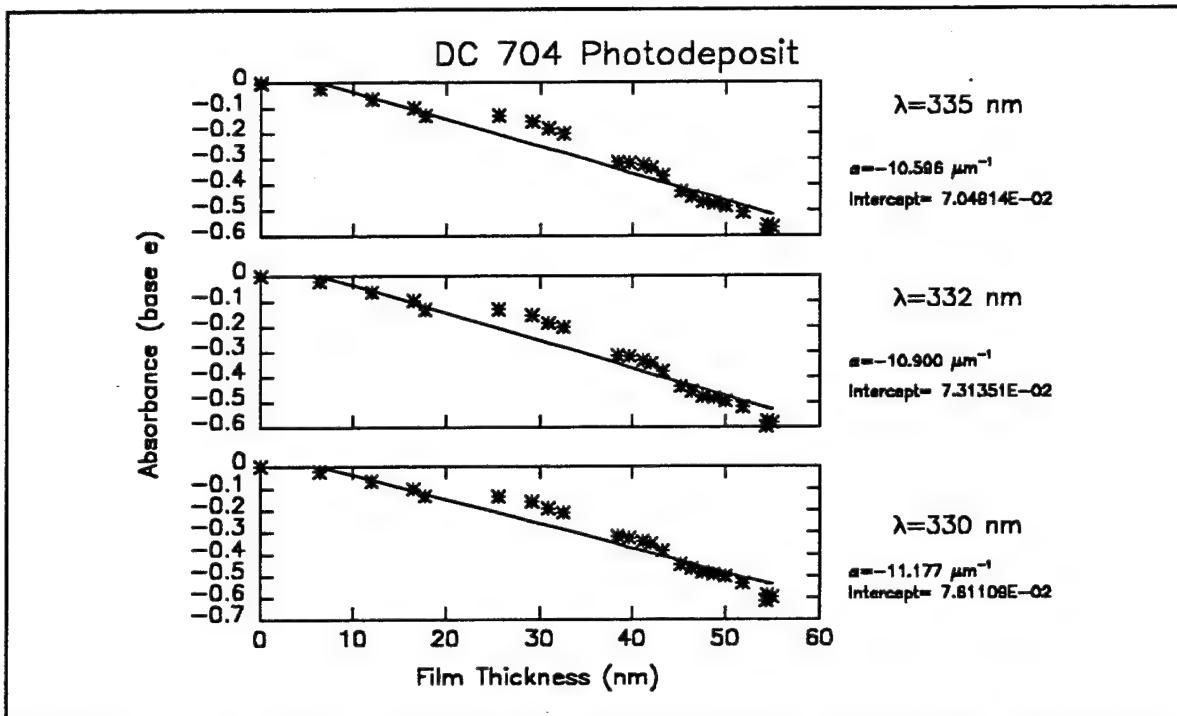


Figure B17i. Fits of measured transmission spectra to the Beer-Lambert absorption law. (Ultraviolet wavelength range)

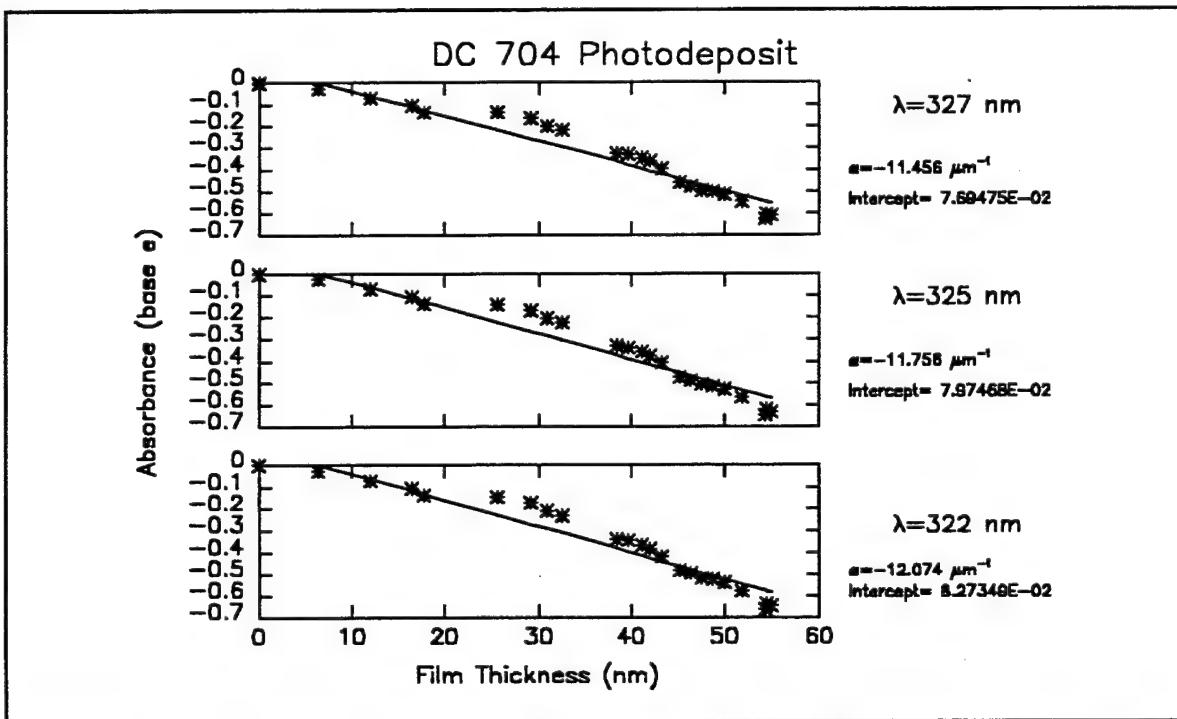


Figure B17j. Fits of measured transmission spectra to the Beer-Lambert absorption law. (Ultraviolet wavelength range)

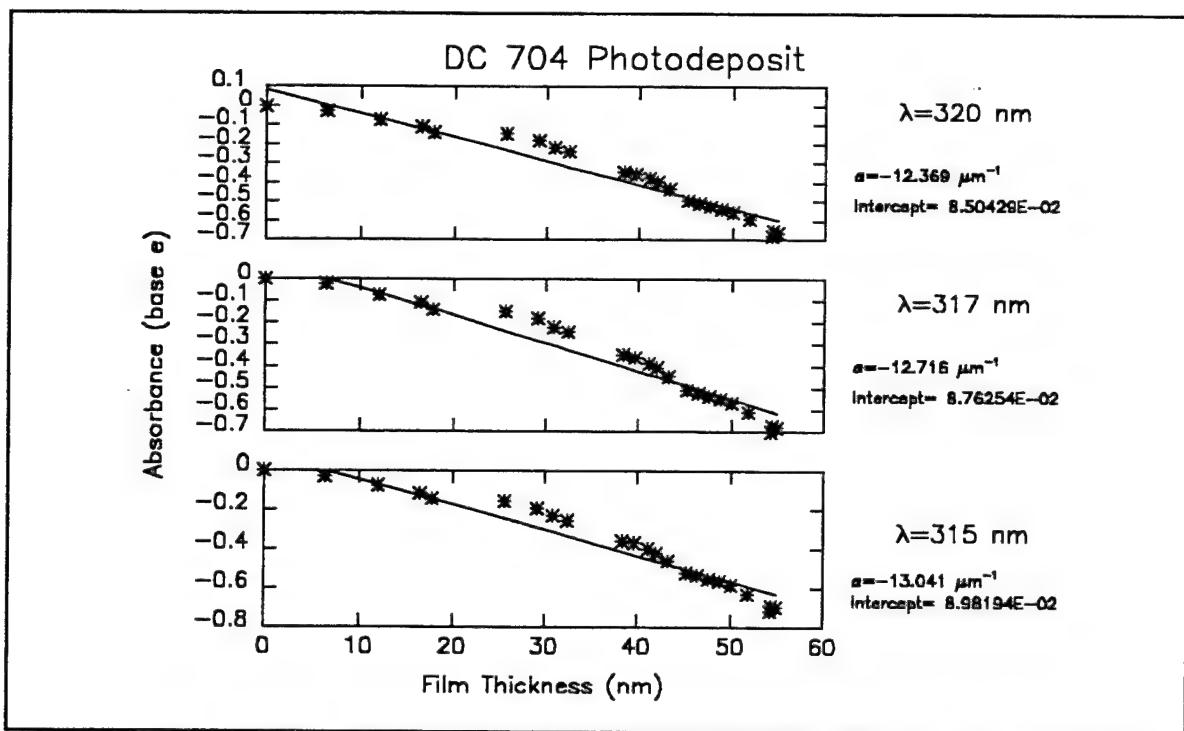


Figure B17k. Fits of measured transmission spectra to the Beer-Lambert absorption law. (Ultraviolet wavelength range)

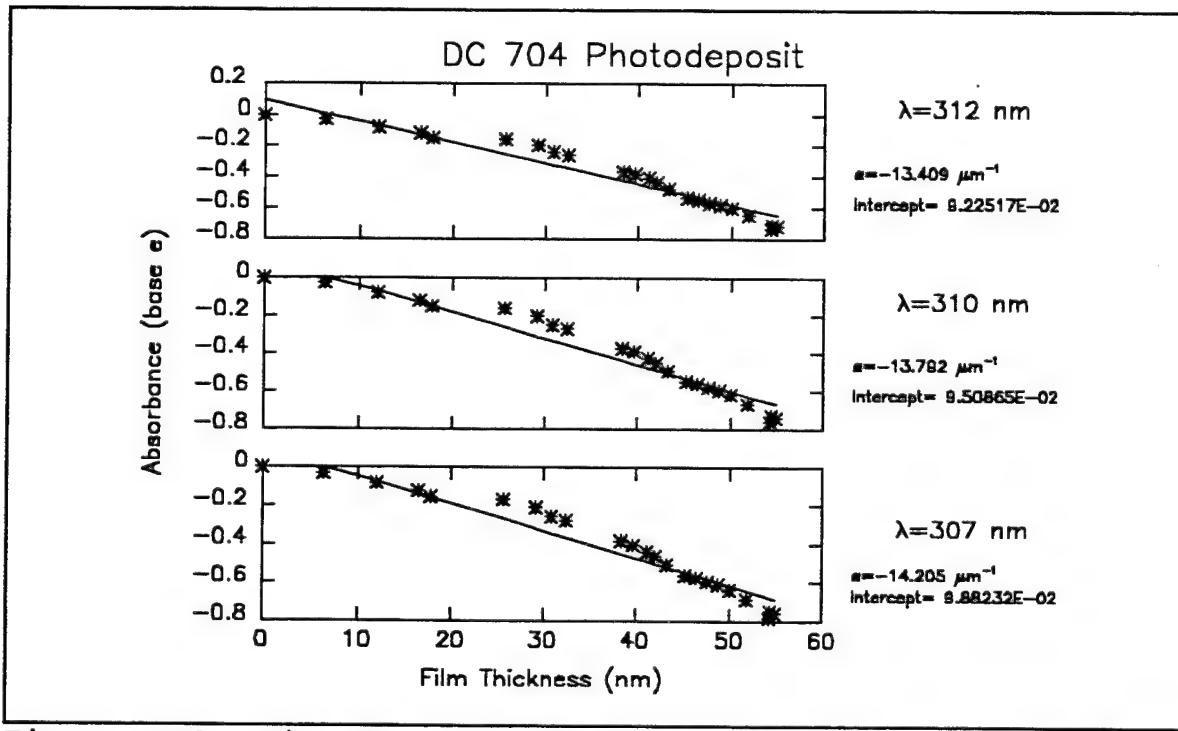


Figure B17l. Fits of measured transmission spectra to the Beer-Lambert absorption law. (Ultraviolet wavelength range)

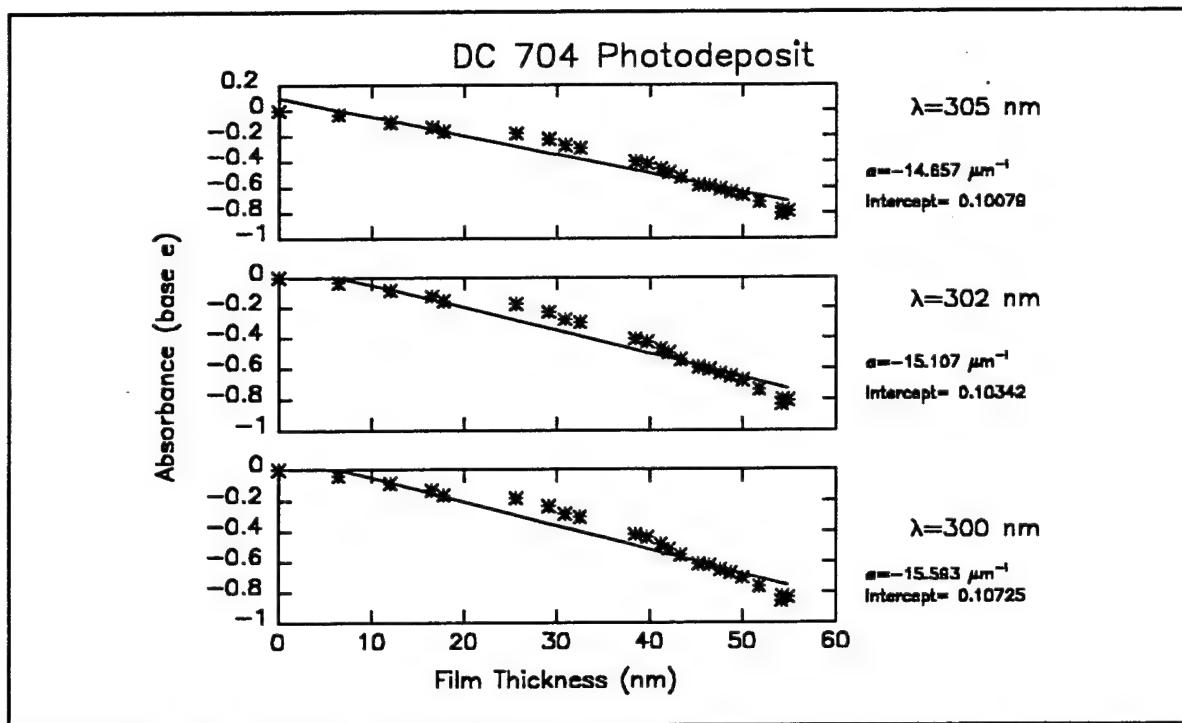


Figure B17m. Fits of measured transmission spectra to the Beer-Lambert absorption law. (Ultraviolet wavelength range)

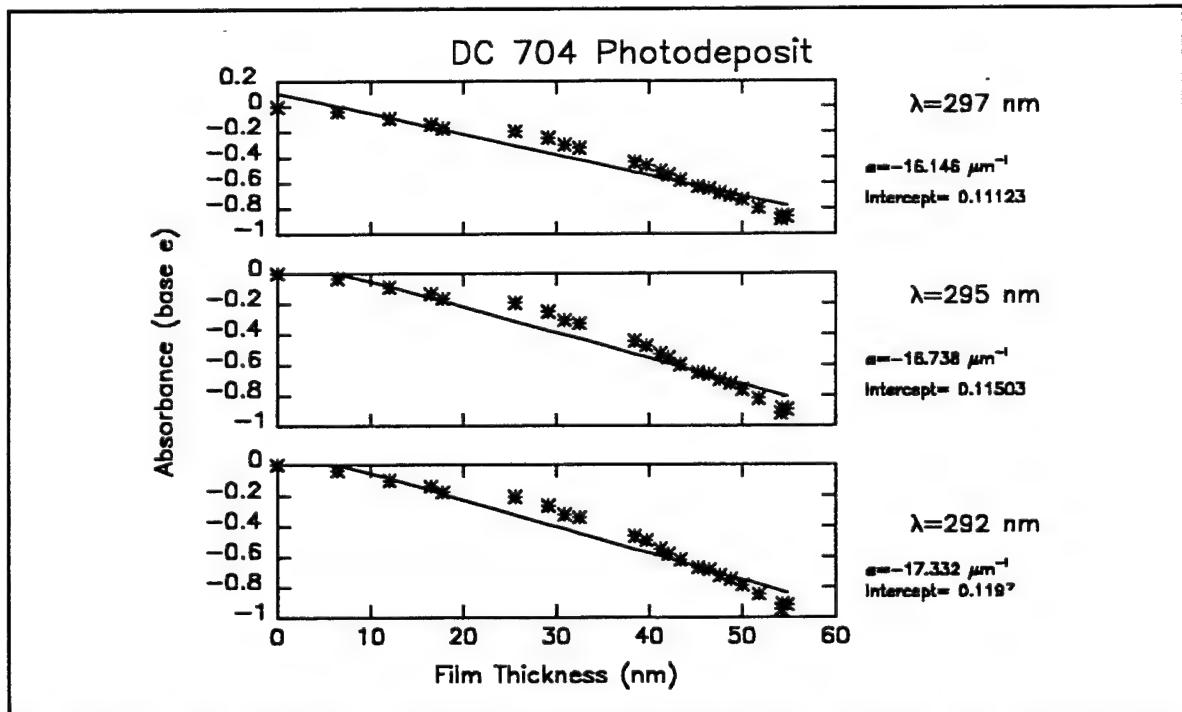


Figure B17n. Fits of measured transmission spectra to the Beer-Lambert absorption law. (Ultraviolet wavelength range)

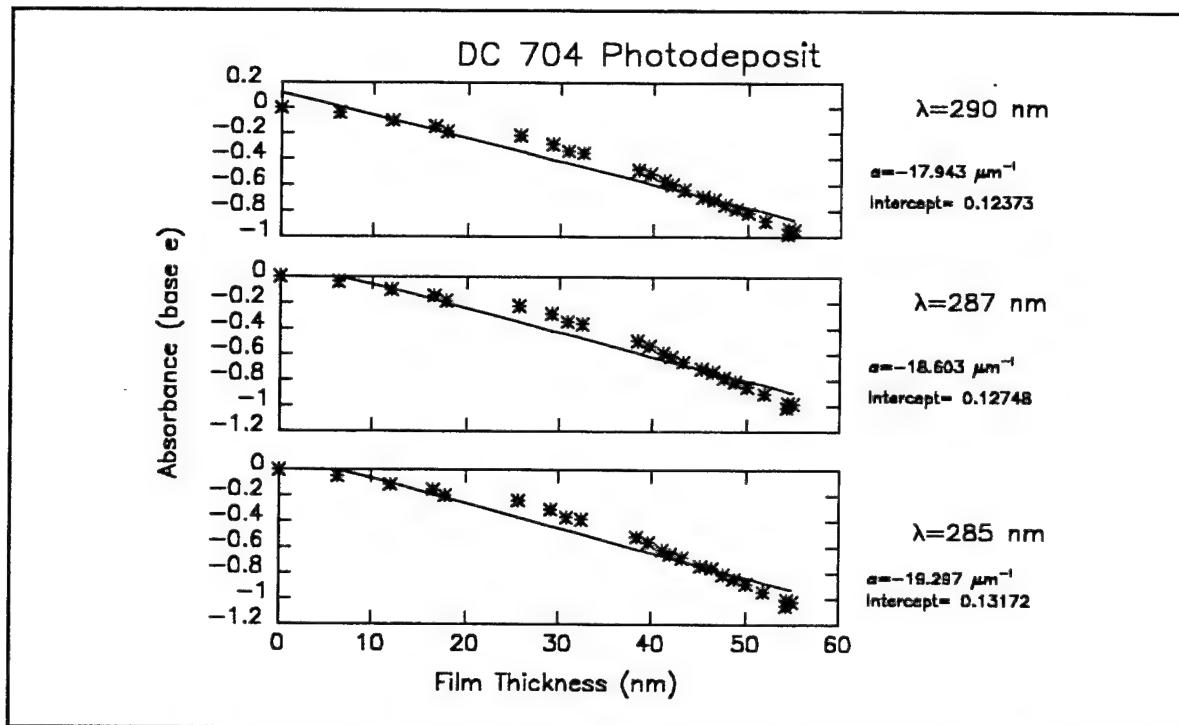


Figure B17o. Fits of measured transmission spectra to the Beer-Lambert absorption law. (Ultraviolet wavelength range)

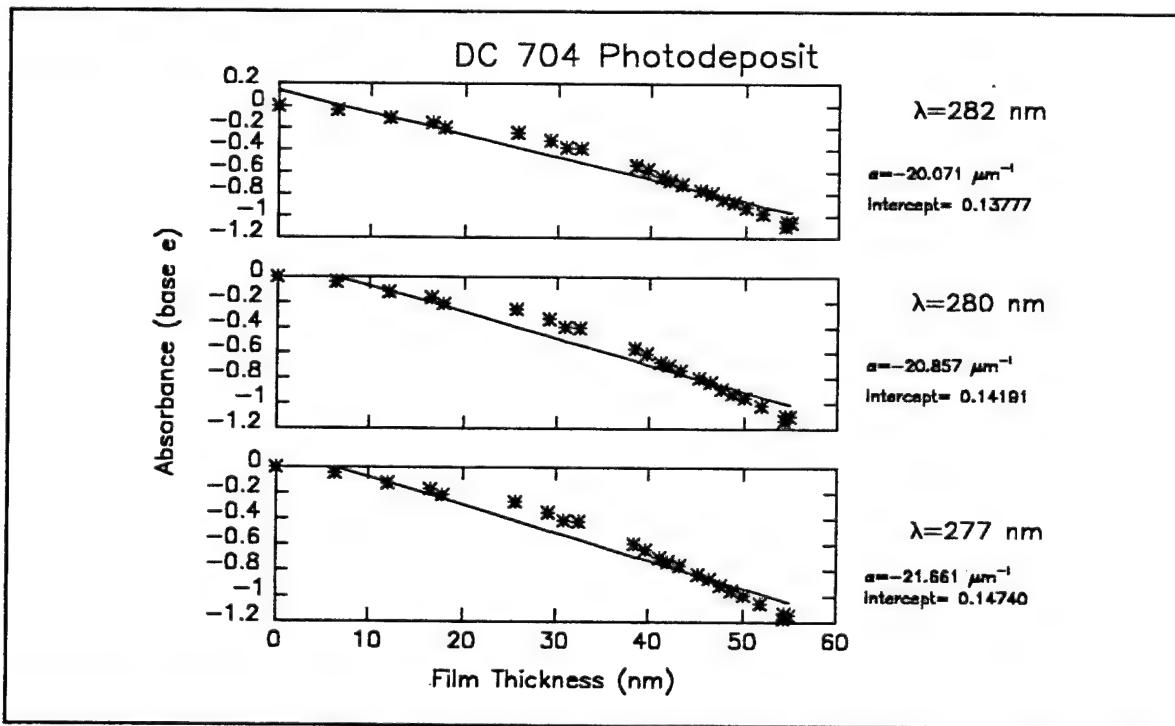


Figure B17p. Fits of measured transmission spectra to the Beer-Lambert absorption law. (Ultraviolet wavelength range)

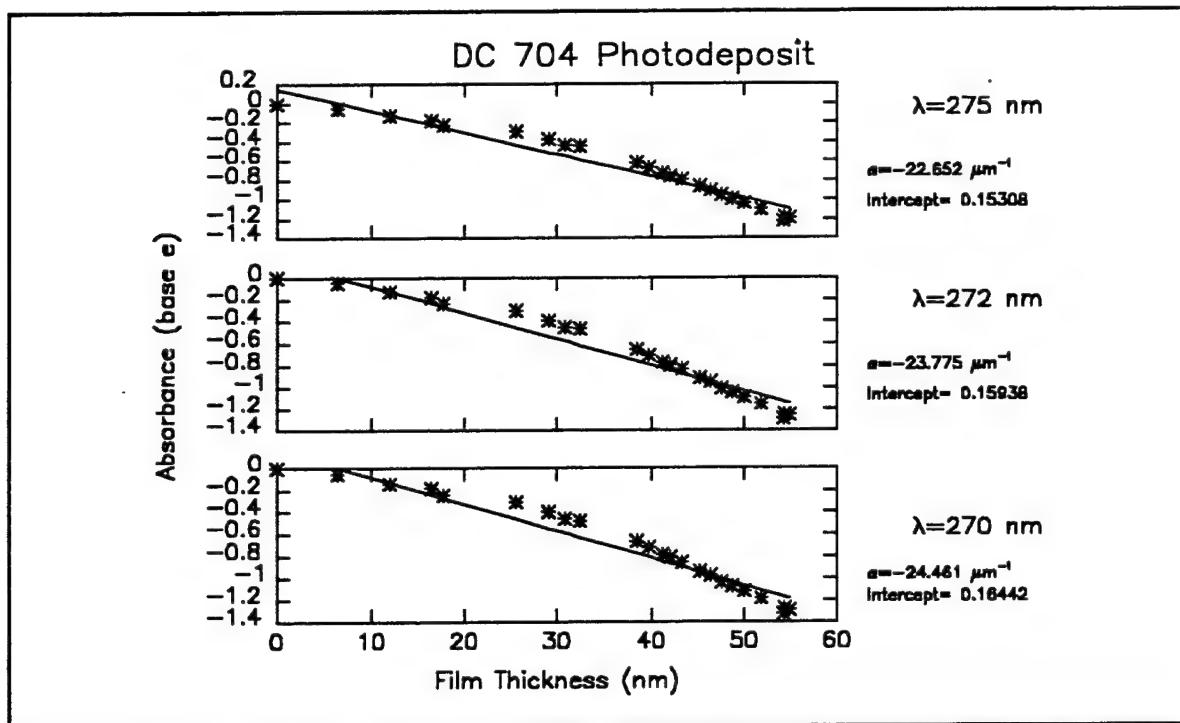


Figure B17q. Fits of measured transmission spectra to the Beer-Lambert absorption law. (Ultraviolet wavelength range)

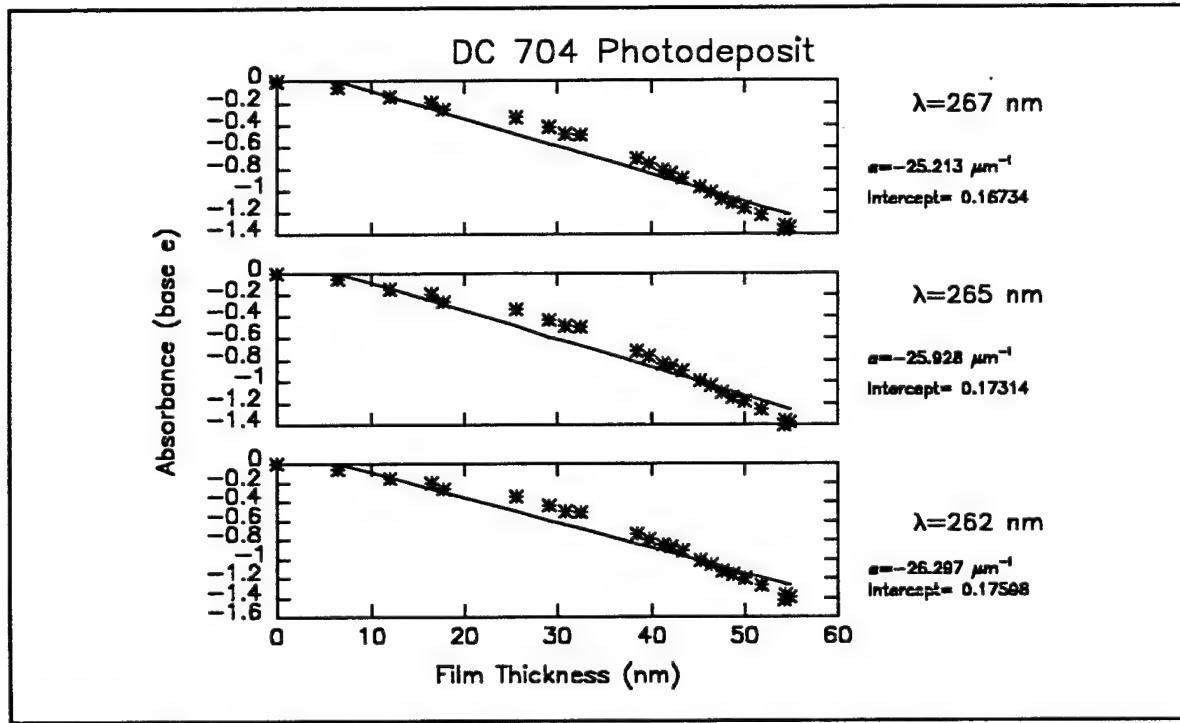


Figure B17r. Fits of measured transmission spectra to the Beer-Lambert absorption law. (Ultraviolet wavelength range)

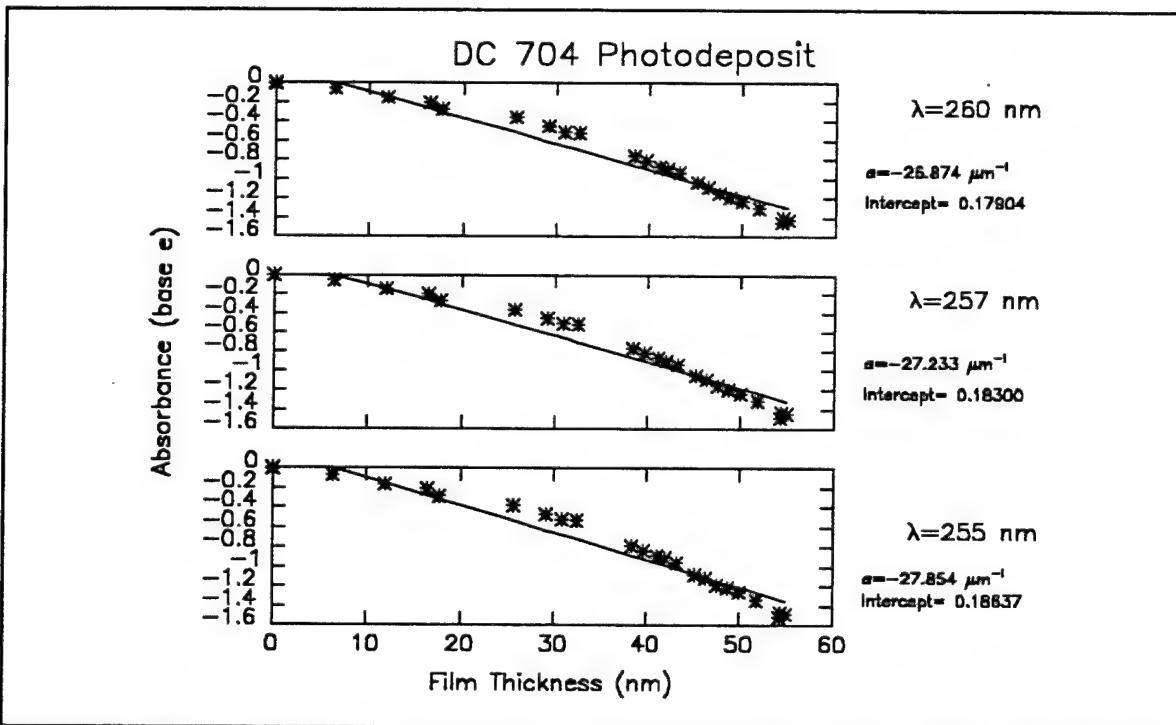


Figure B17s. Fits of measured transmission spectra to the Beer-Lambert absorption law. (Ultraviolet wavelength range)

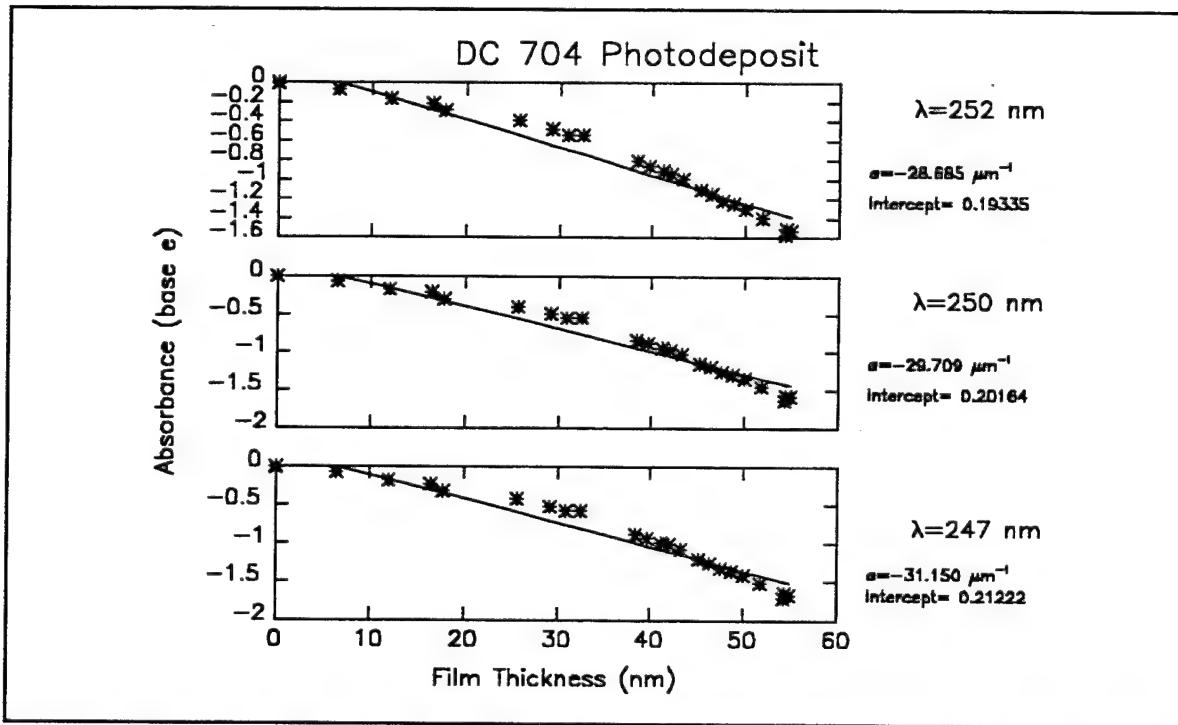


Figure B17t. Fits of measured transmission spectra to the Beer-Lambert absorption law. (Ultraviolet wavelength range)

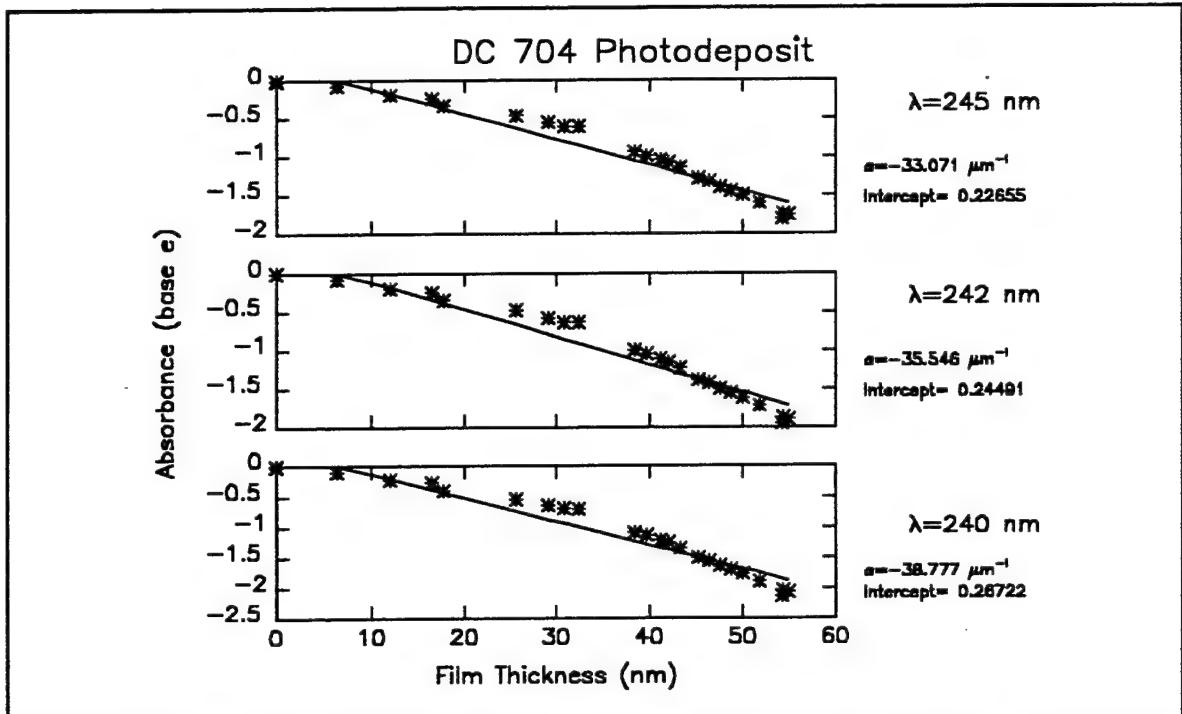


Figure B17u. Fits of measured transmission spectra to the Beer-Lambert absorption law. (Ultraviolet wavelength range)

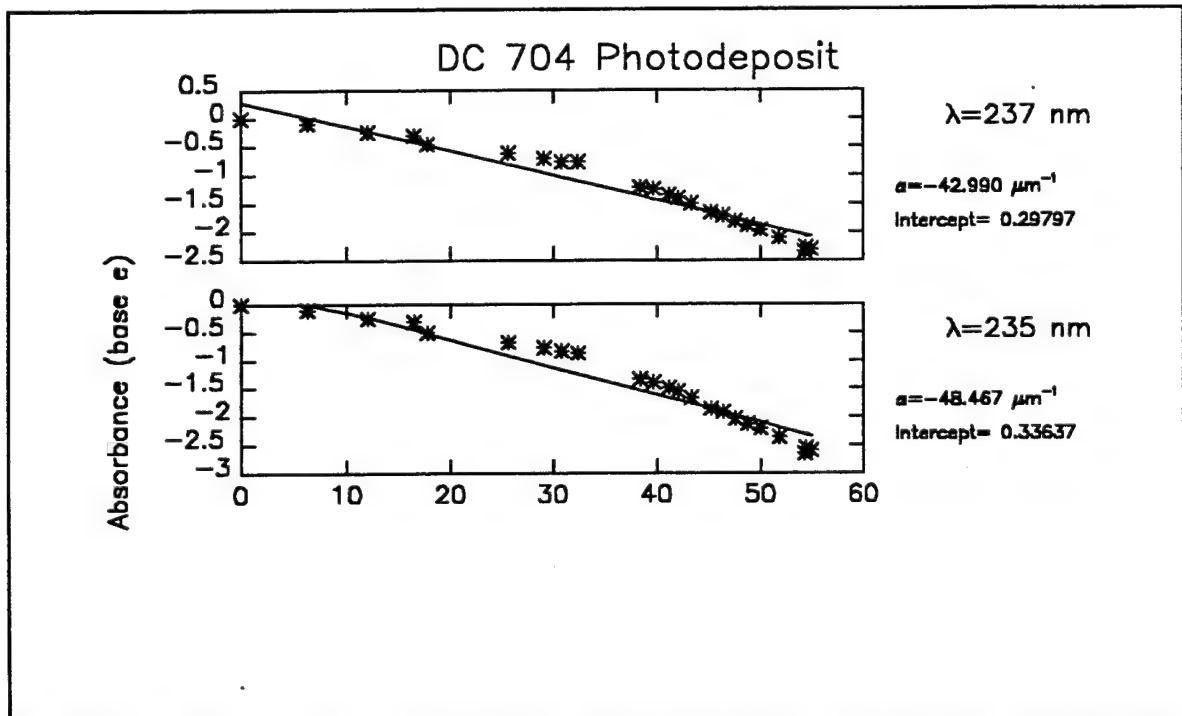


Figure B17v. Fits of measured transmission spectra to the Beer-Lambert absorption law. (Ultraviolet wavelength range)

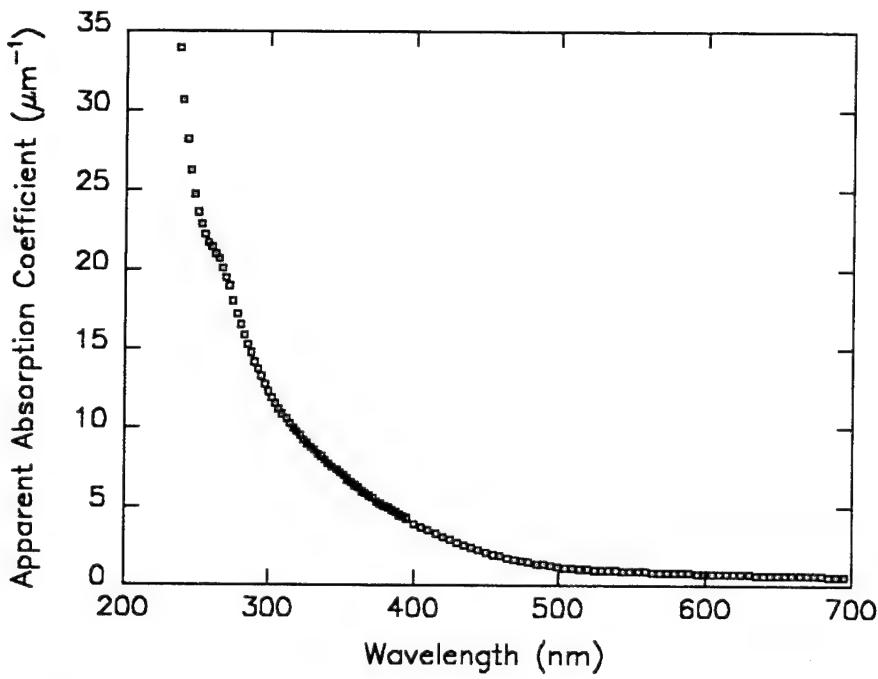


Figure B18. Apparent absorption coefficient obtained from the constrained data fits. Linear plot

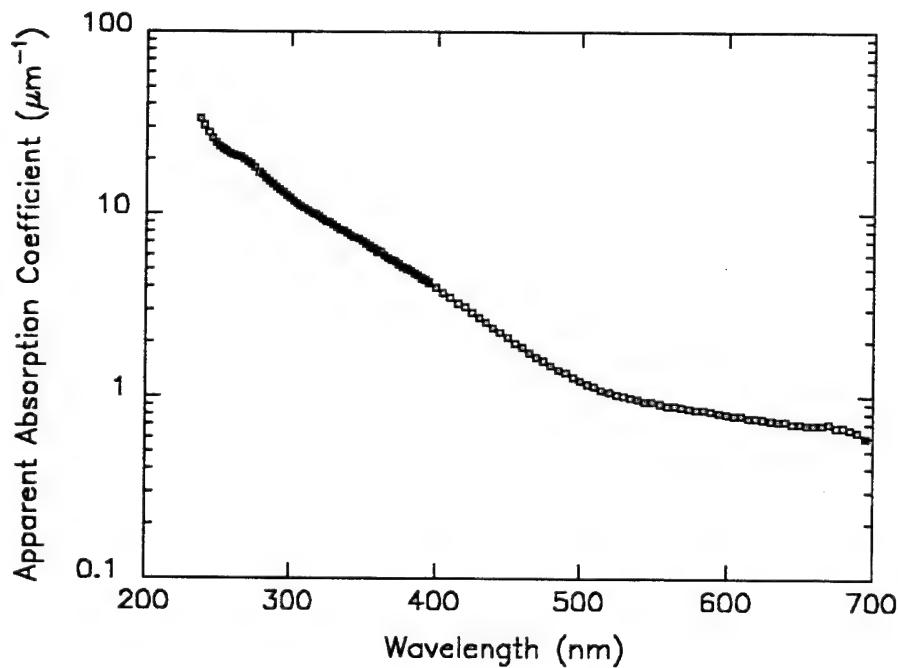


Figure B19. Apparent absorption coefficient obtained from the constrained data fits. Log plot

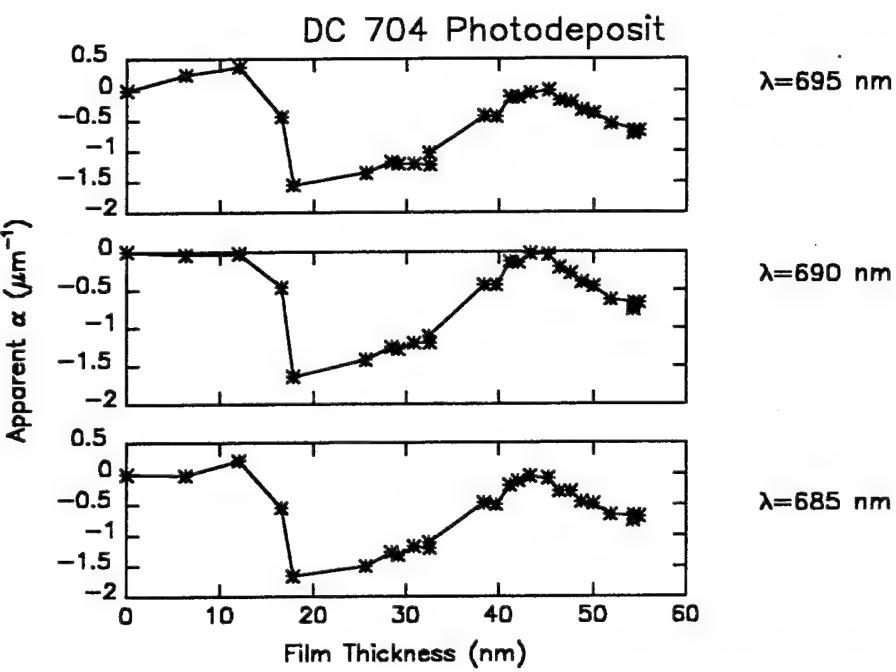


Figure B20a Computed values of α_j for photochemically deposited DC 704 (see eq. B2).

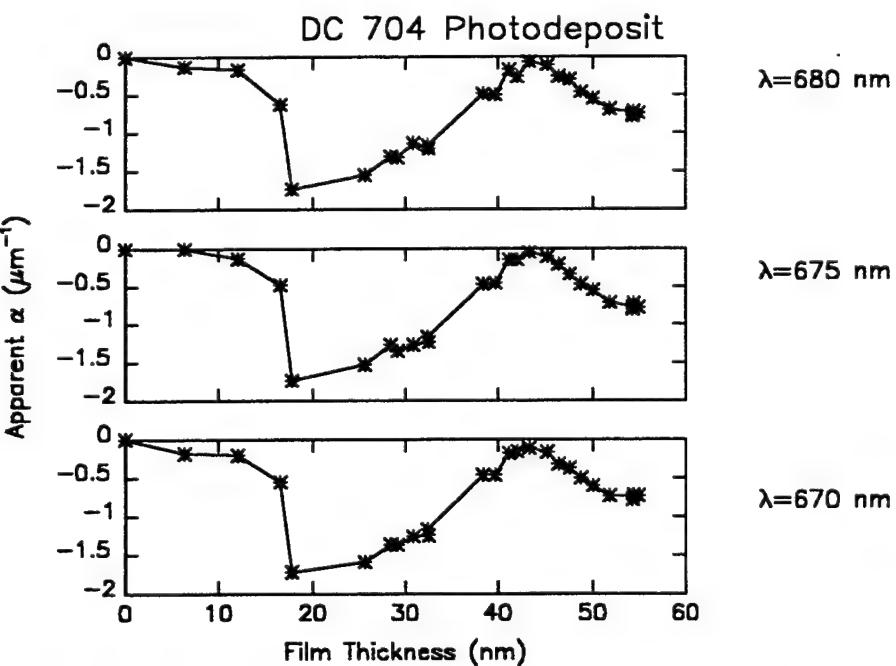


Figure B20b Computed values of α_j for photochemically deposited DC 704 (see eq. B2).

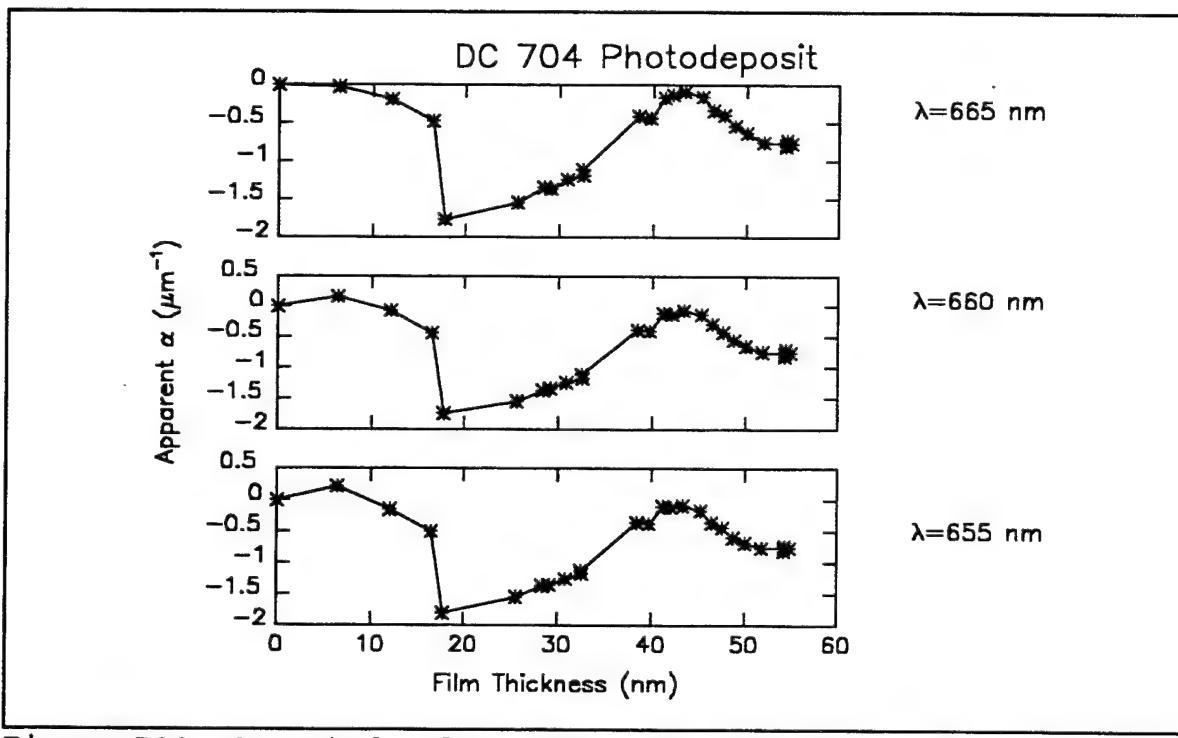


Figure B20c Computed values of α_j for photochemically deposited DC 704 (see eq. B2).

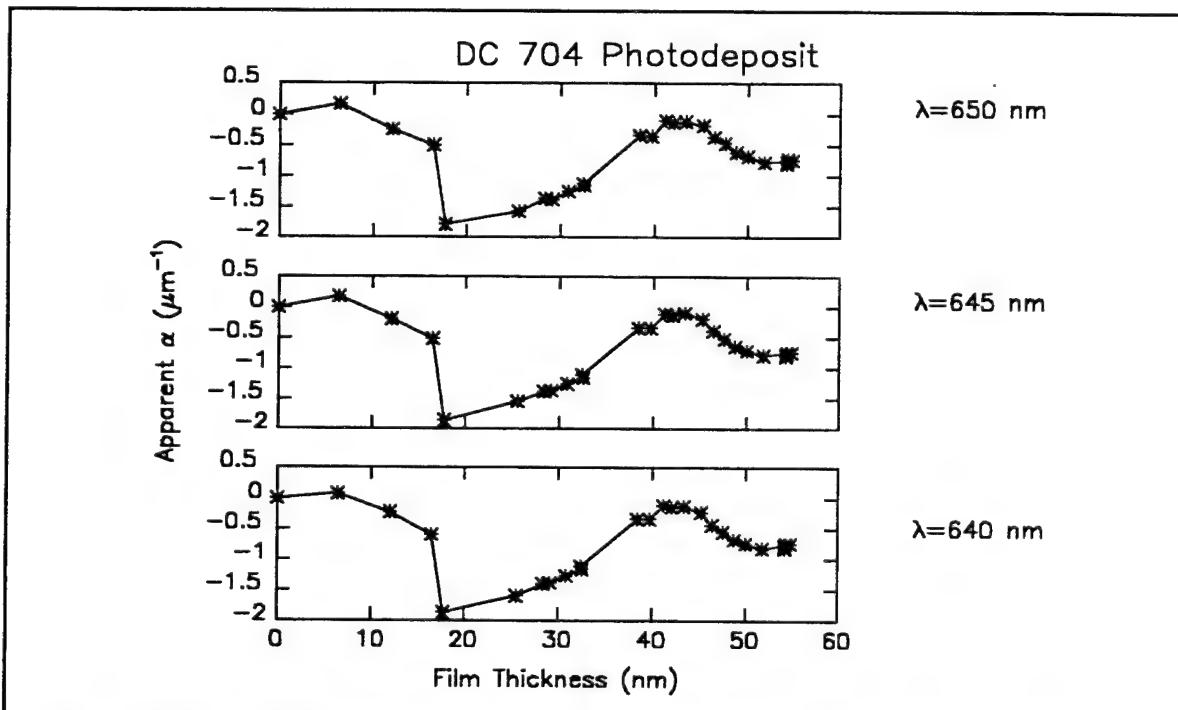


Figure B20d Computed values of α_j for photochemically deposited DC 704 (see eq. B2).

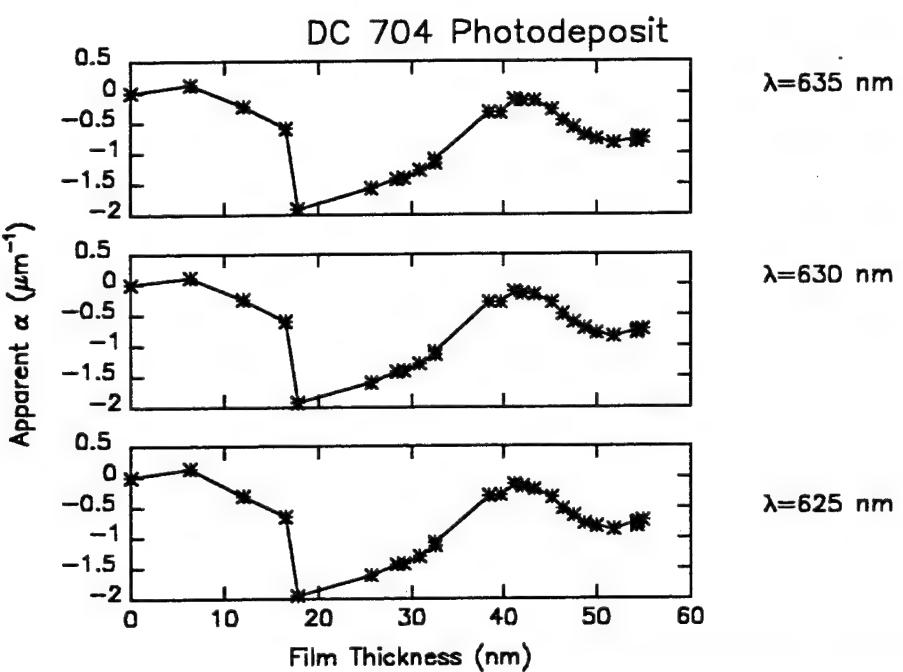


Figure B20e Computed values of α_i for photochemically deposited DC 704 (see eq. B2).

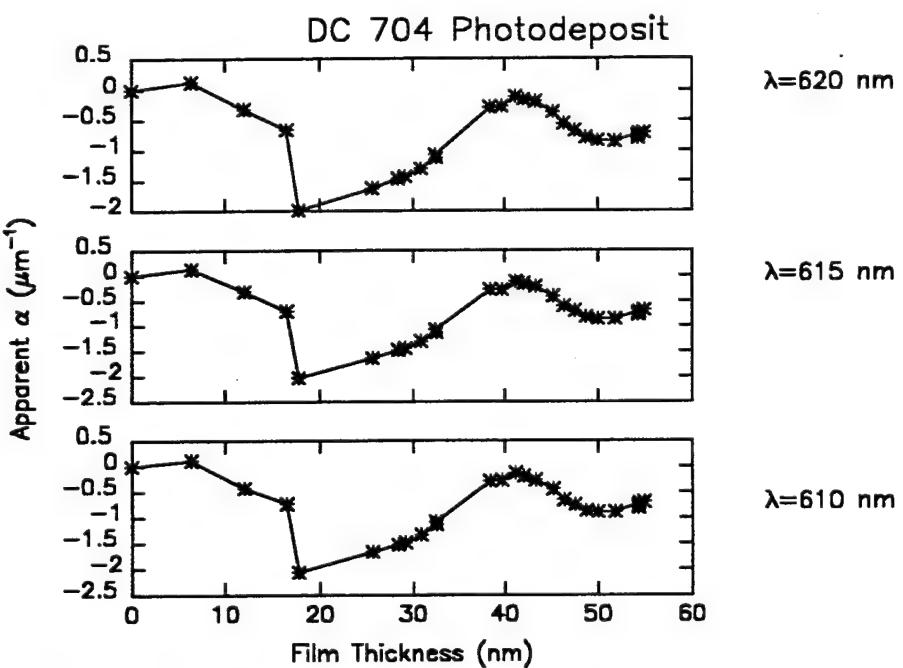


Figure B20f Computed values of α_i for photochemically deposited DC 704 (see eq. B2).

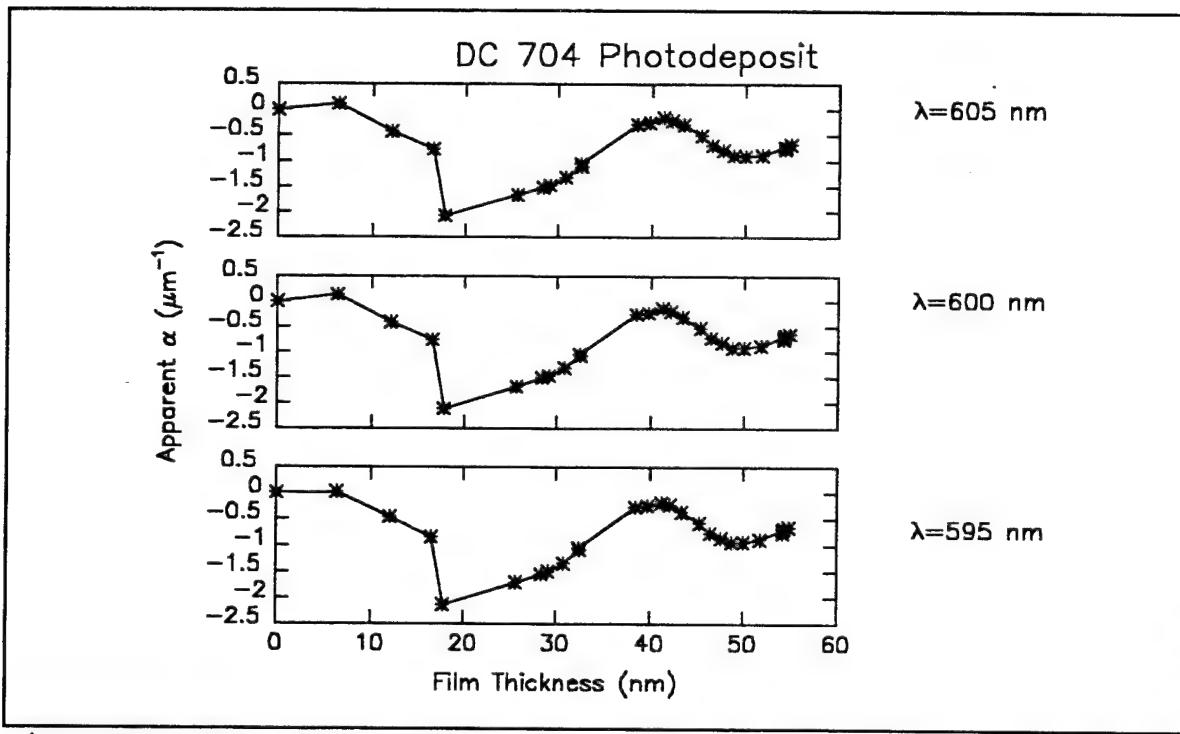


Figure B20g Computed values of α_i for photochemically deposited DC 704 (see eq. B2).

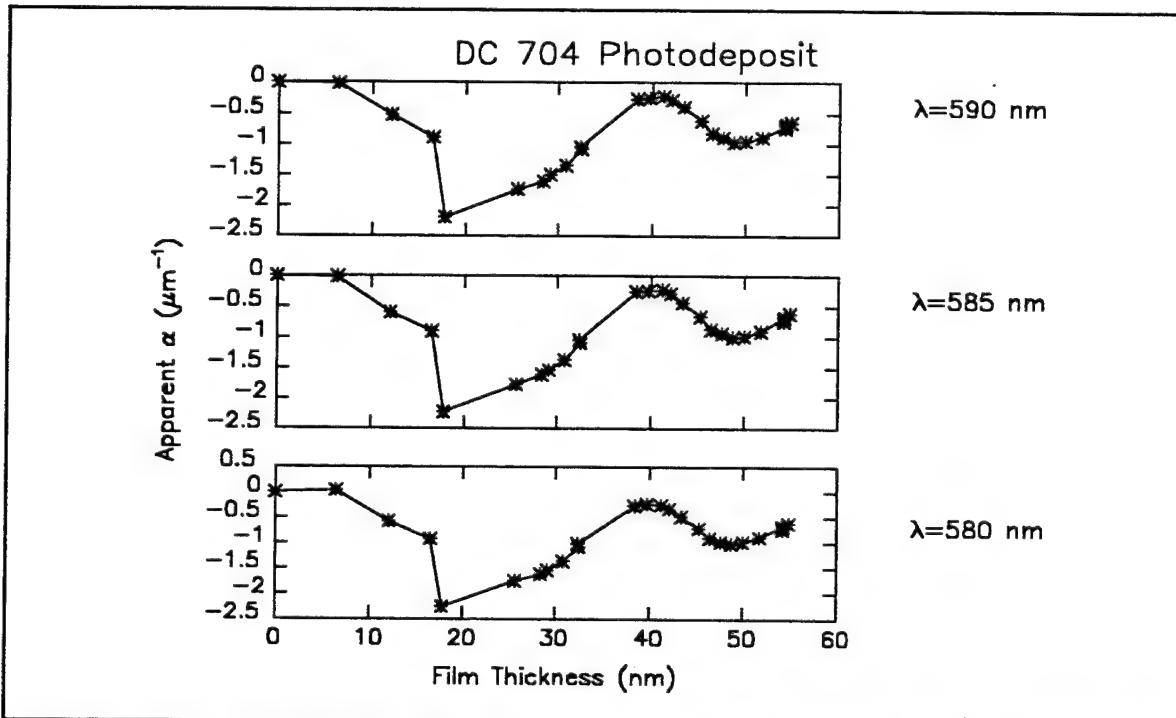


Figure B20h Computed values of α_i for photochemically deposited DC 704 (see eq. B2).

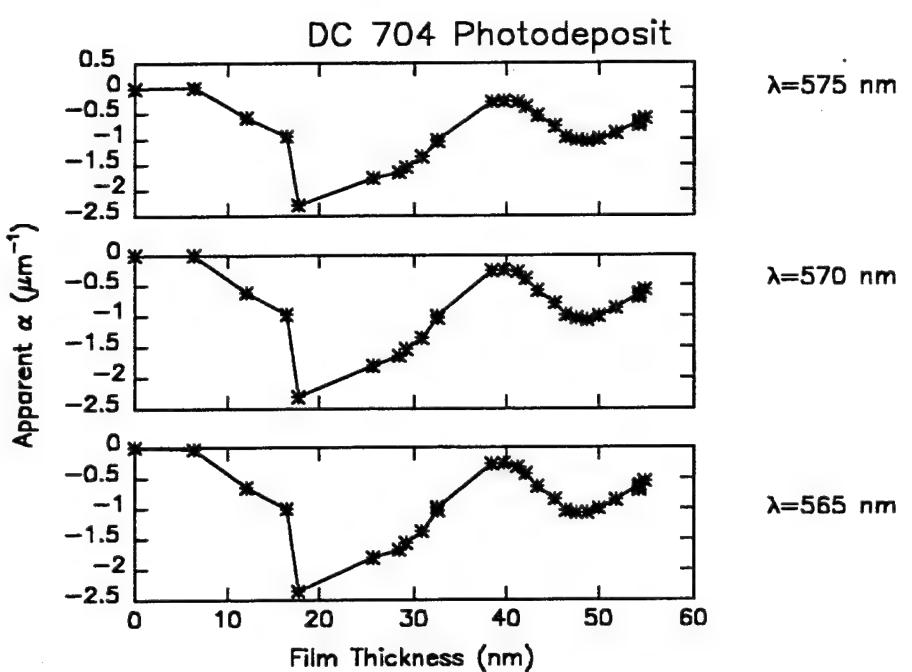


Figure B20i Computed values of α_j for photochemically deposited DC 704 (see eq. B2).

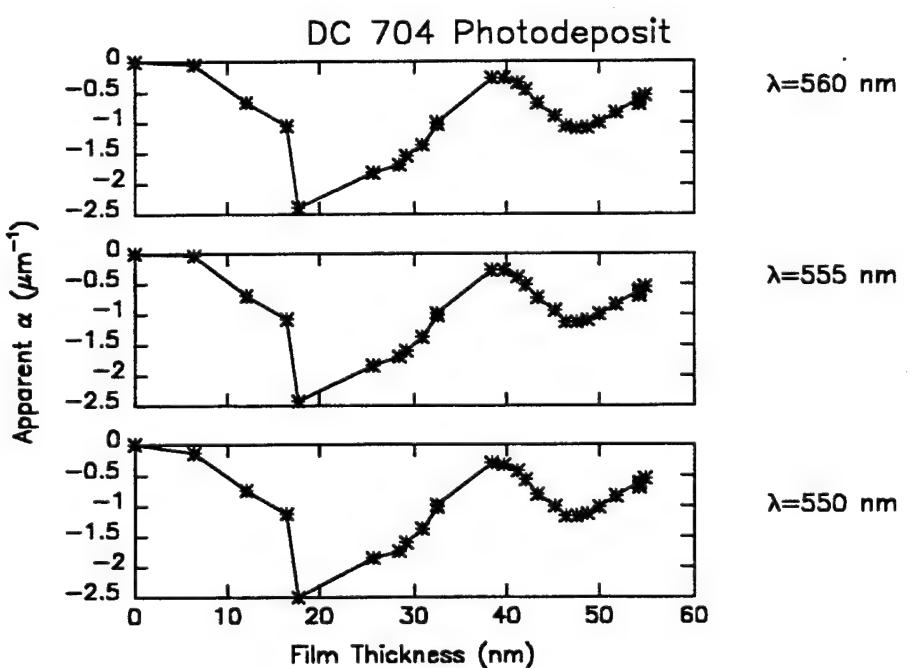


Figure B20j Computed values of α_j for photochemically deposited DC 704 (see eq. B2).

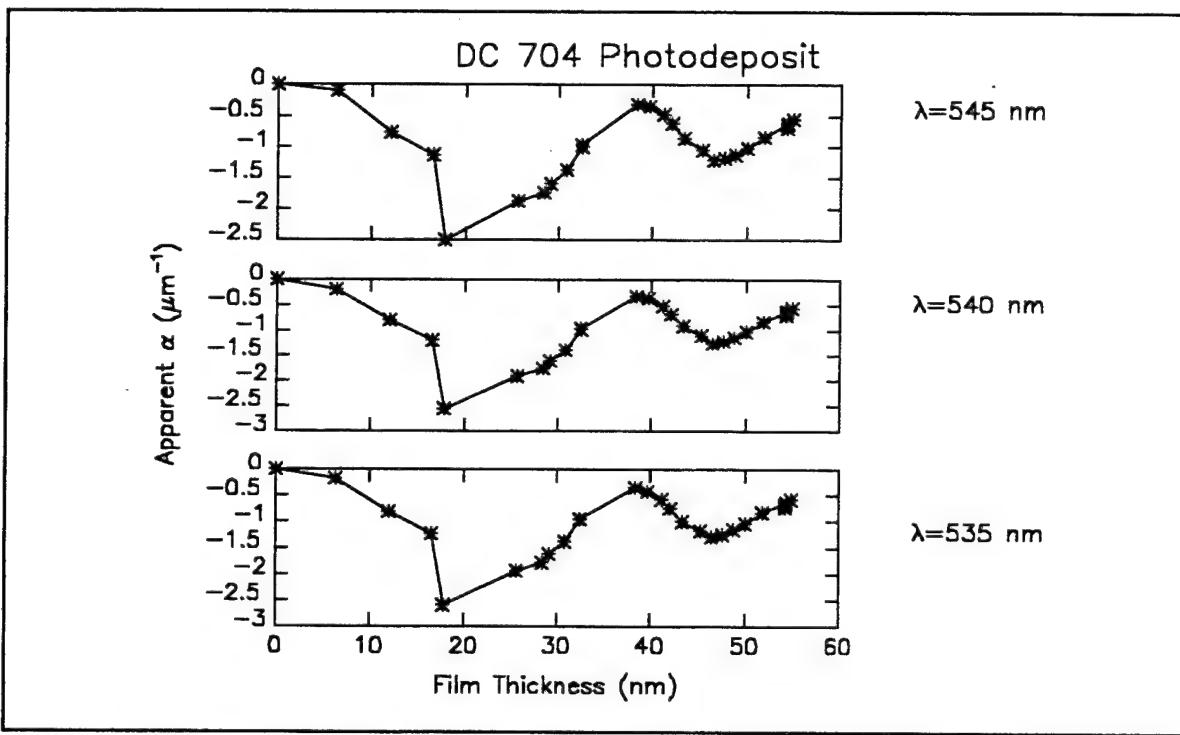


Figure B20k Computed values of α_j for photochemically deposited DC 704 (see eq. B2).

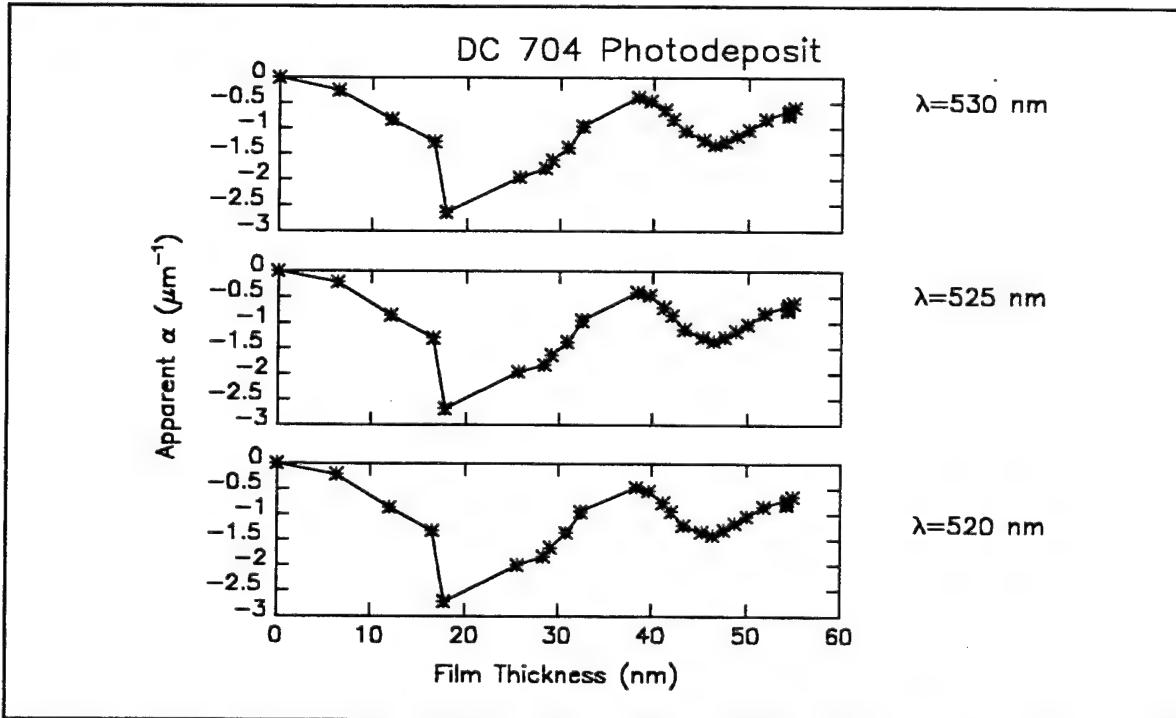


Figure B20l Computed values of α_j for photochemically deposited DC 704 (see eq. B2).

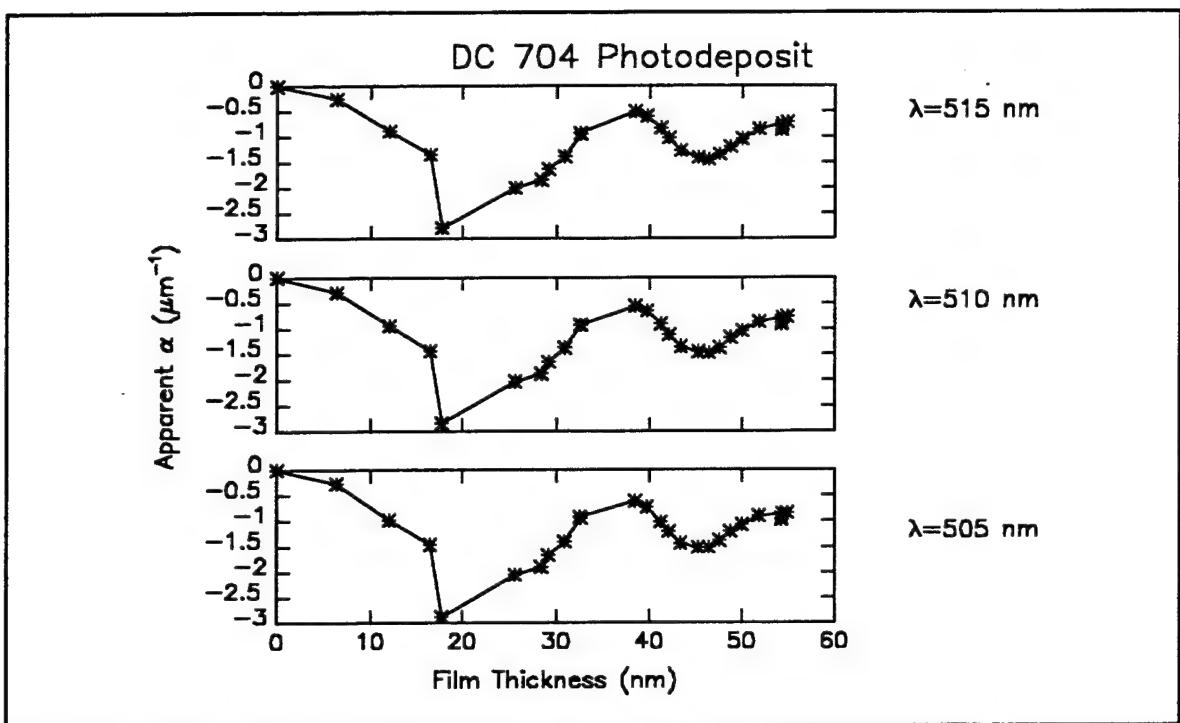


Figure B20m Computed values of α_j for photochemically deposited DC 704 (see eq. B2).

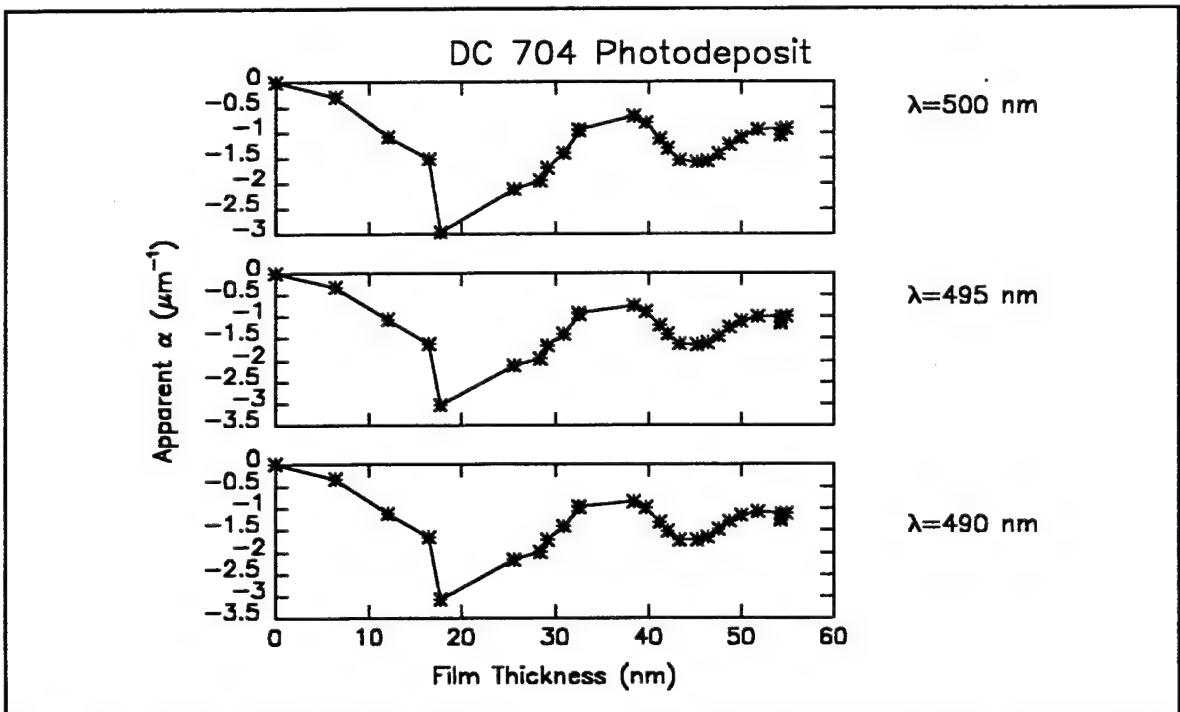


Figure B20n Computed values of α_j for photochemically deposited DC 704 (see eq. B2).

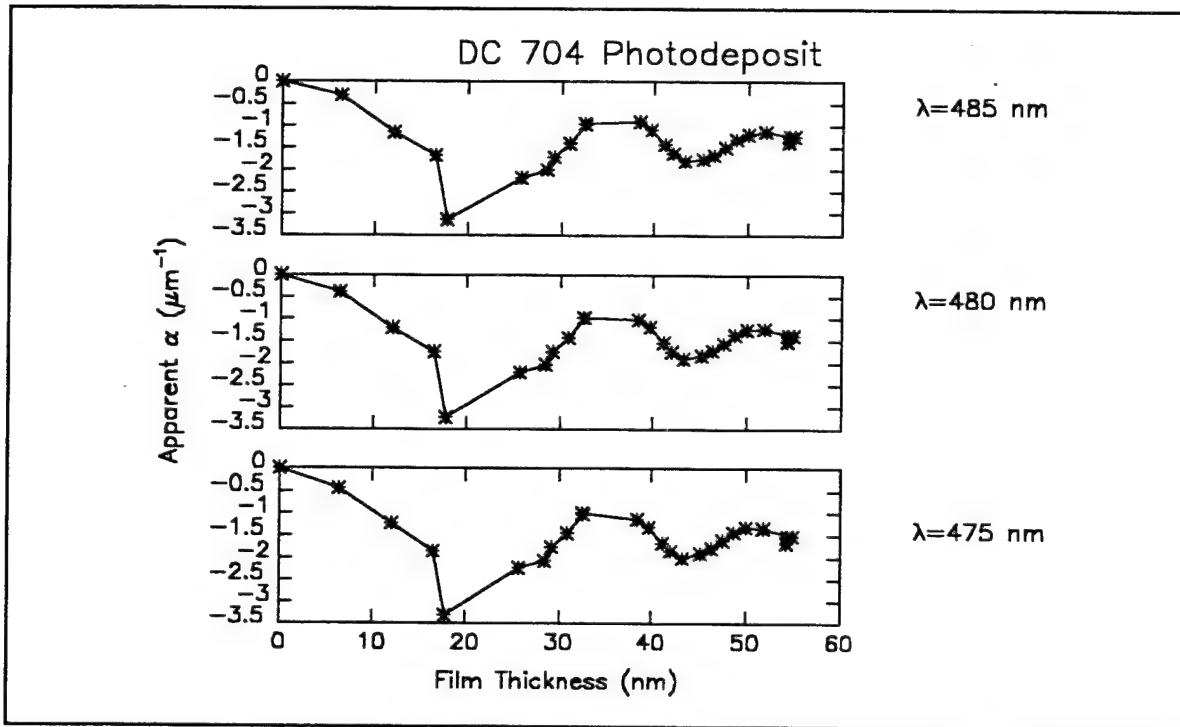


Figure B20o Computed values of α_i for photochemically deposited DC 704 (see eq. B2).

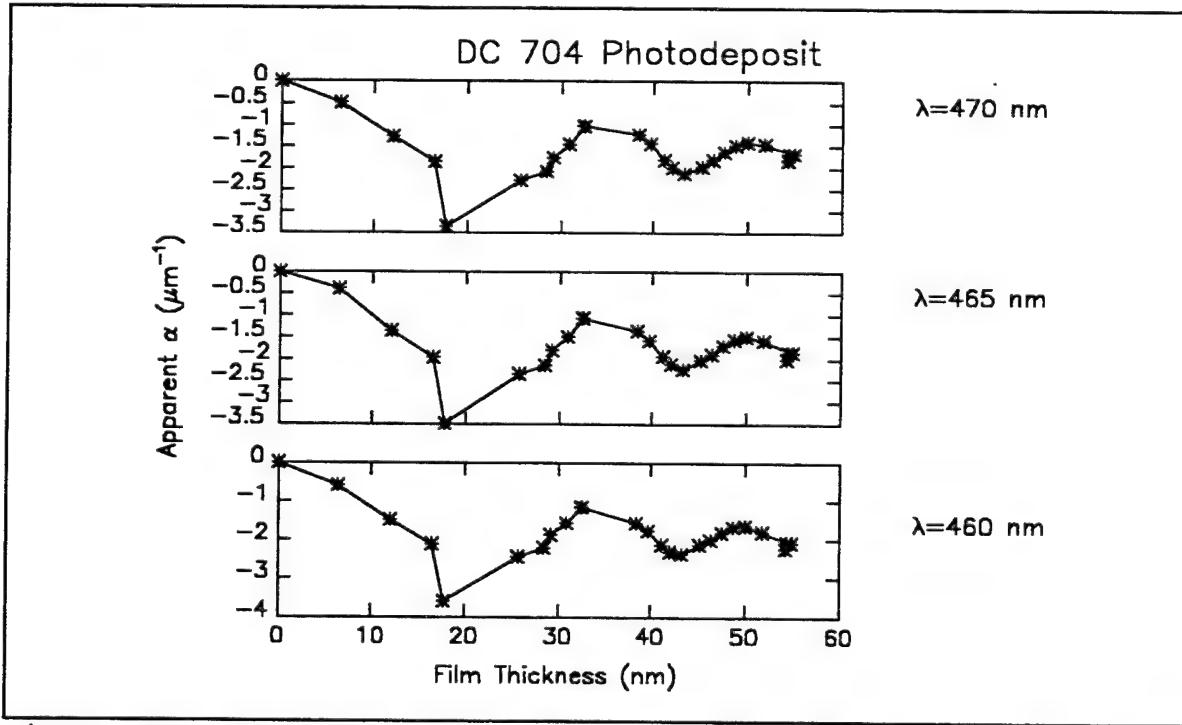


Figure B20p Computed values of α_i for photochemically deposited DC 704 (see eq. B2).

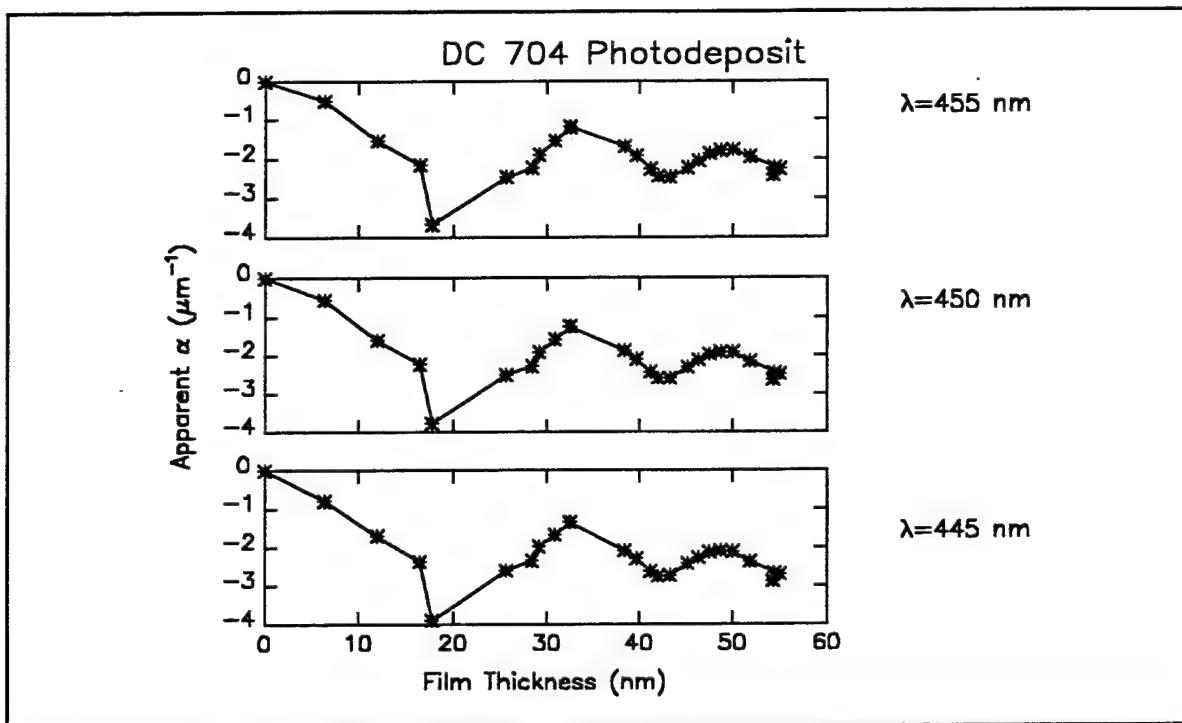


Figure B20q Computed values of α_i for photochemically deposited DC 704 (see eq. B2).

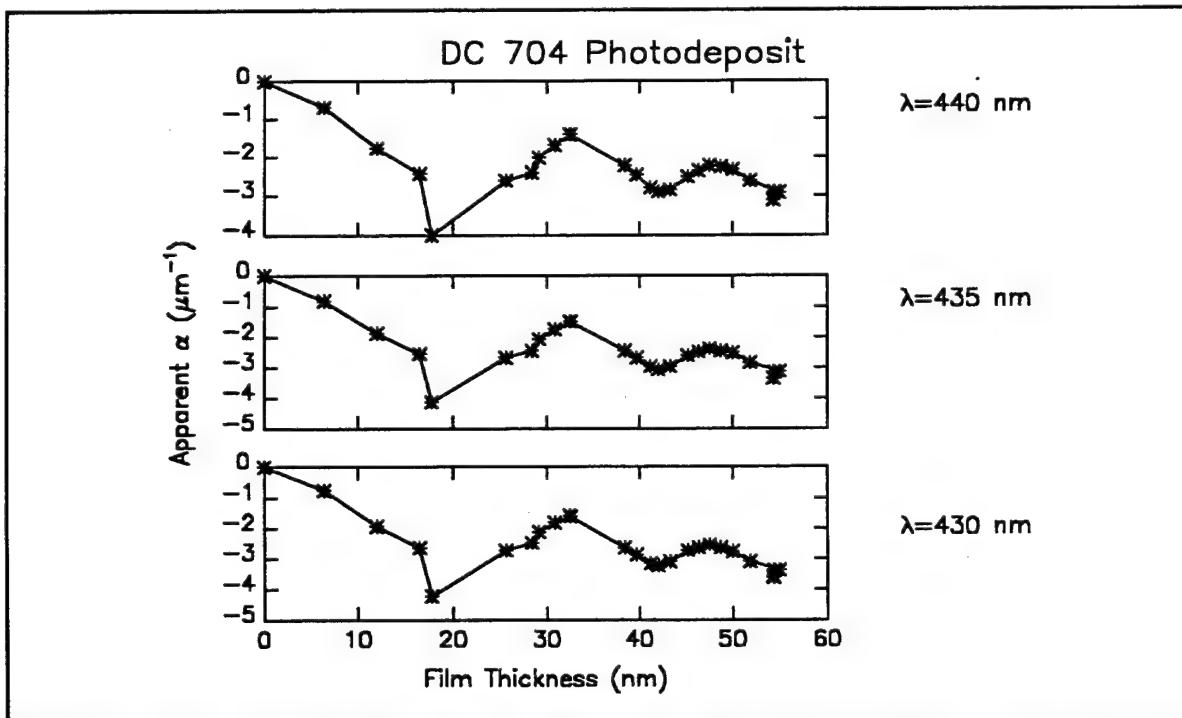


Figure B20r Computed values of α_i for photochemically deposited DC 704 (see eq. B2).

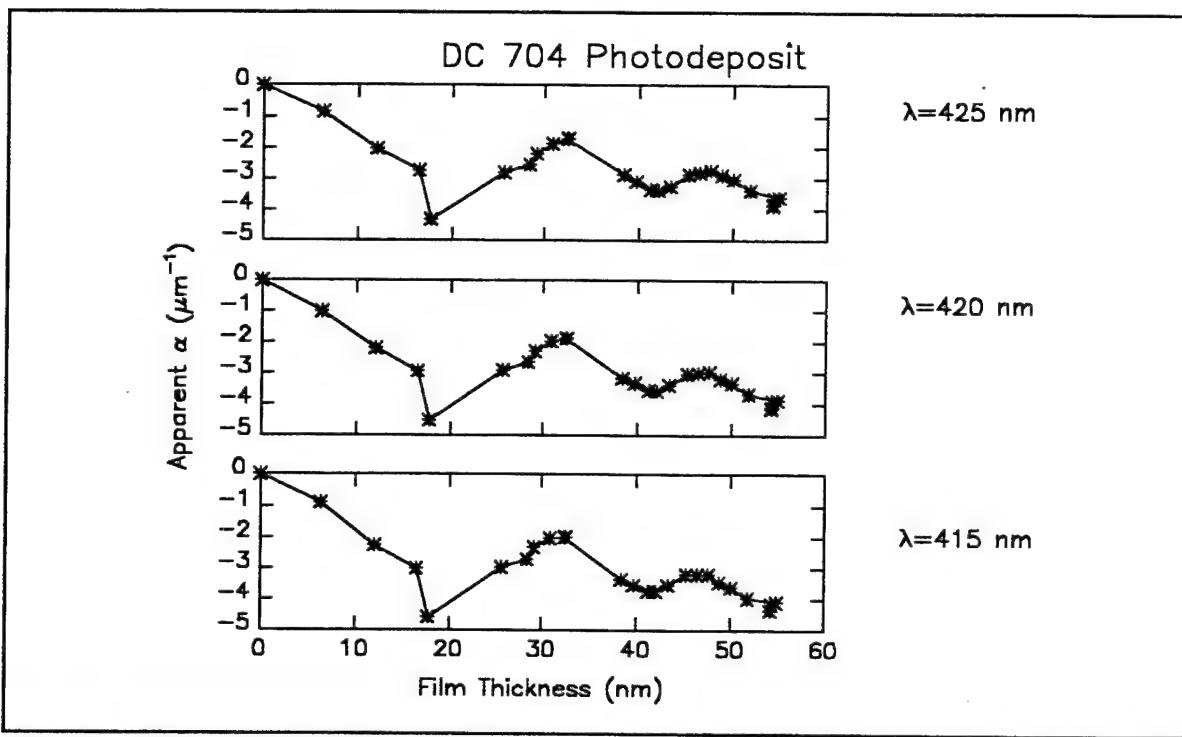


Figure B20s Computed values of α_j for photochemically deposited DC 704 (see eq. B2).

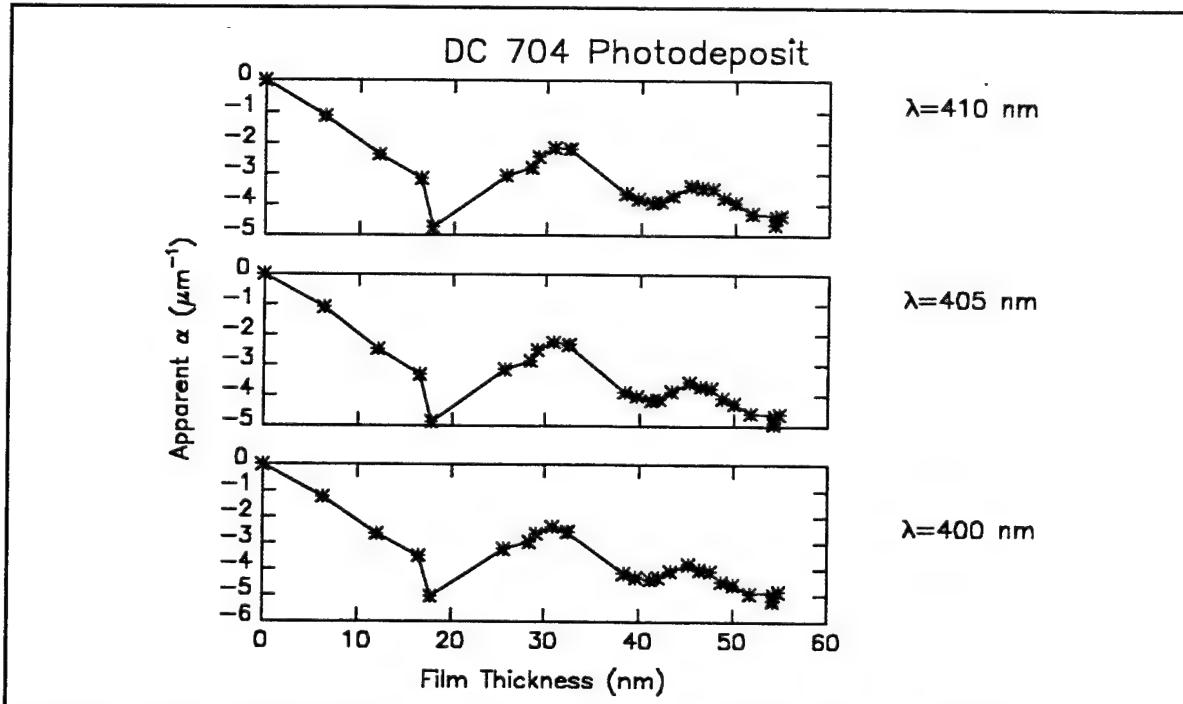


Figure B20t Computed values of α_j for photochemically deposited DC 704 (see eq. B2).

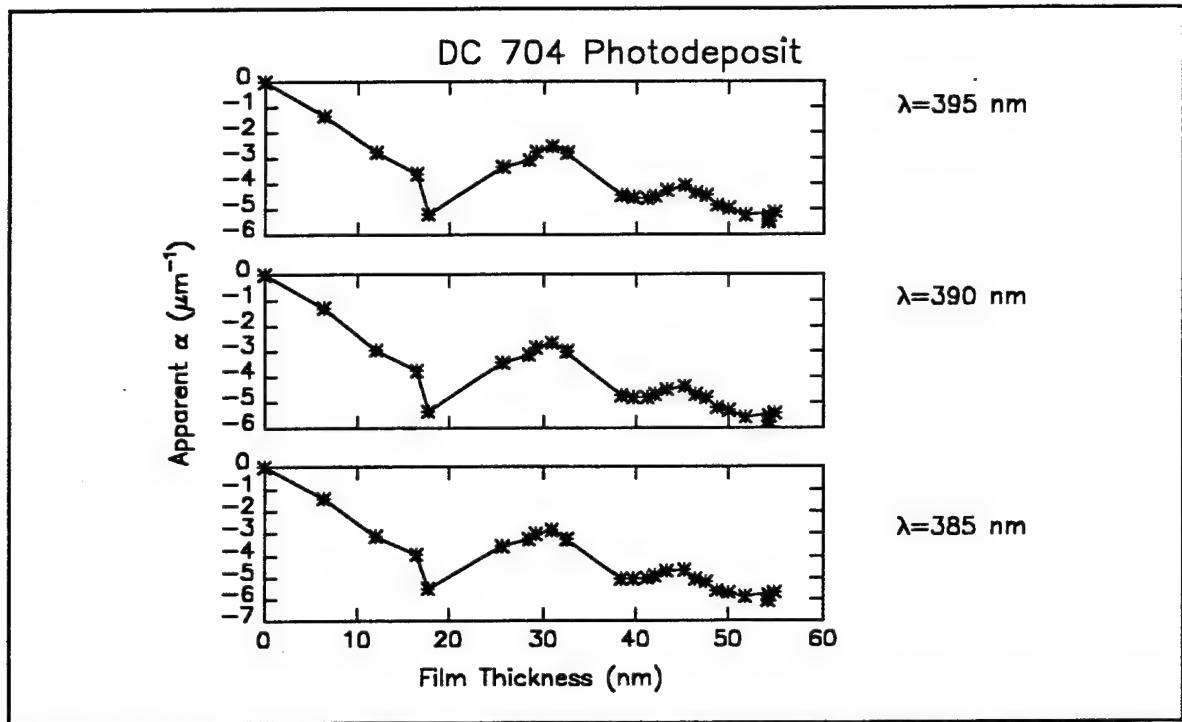


Figure B20u Computed values of α_j for photochemically deposited DC 704 (see eq. B2).

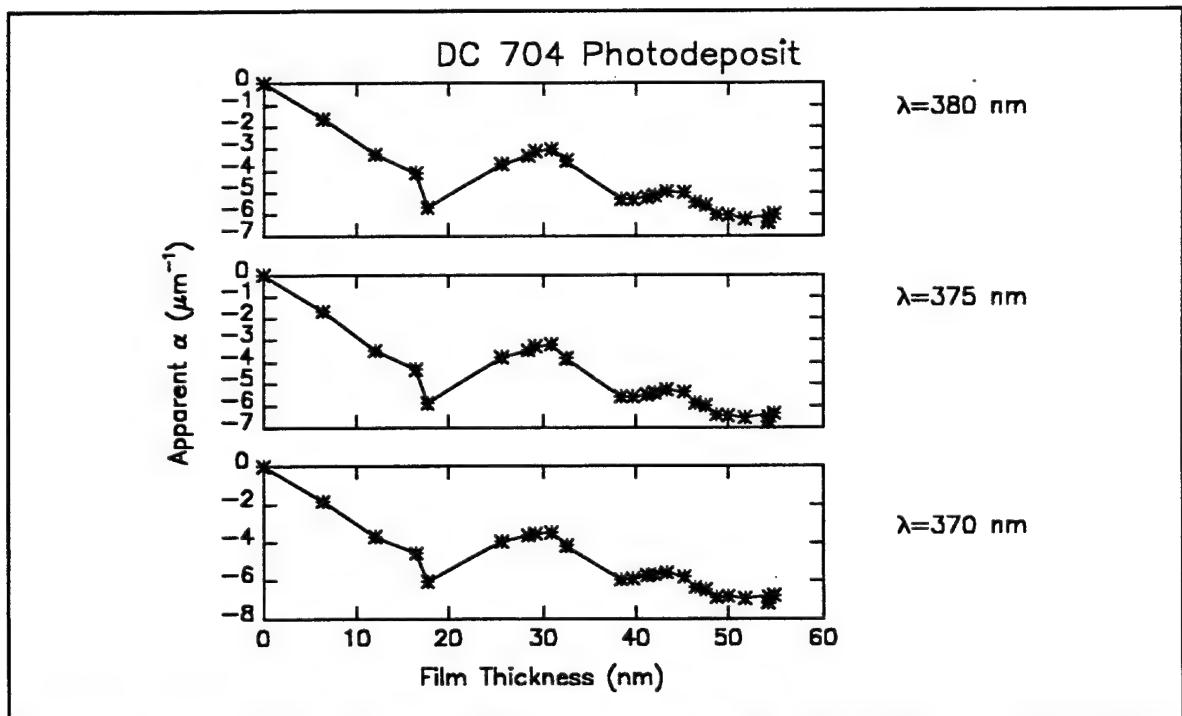


Figure B20v Computed values of α_j for photochemically deposited DC 704 (see eq. B2).

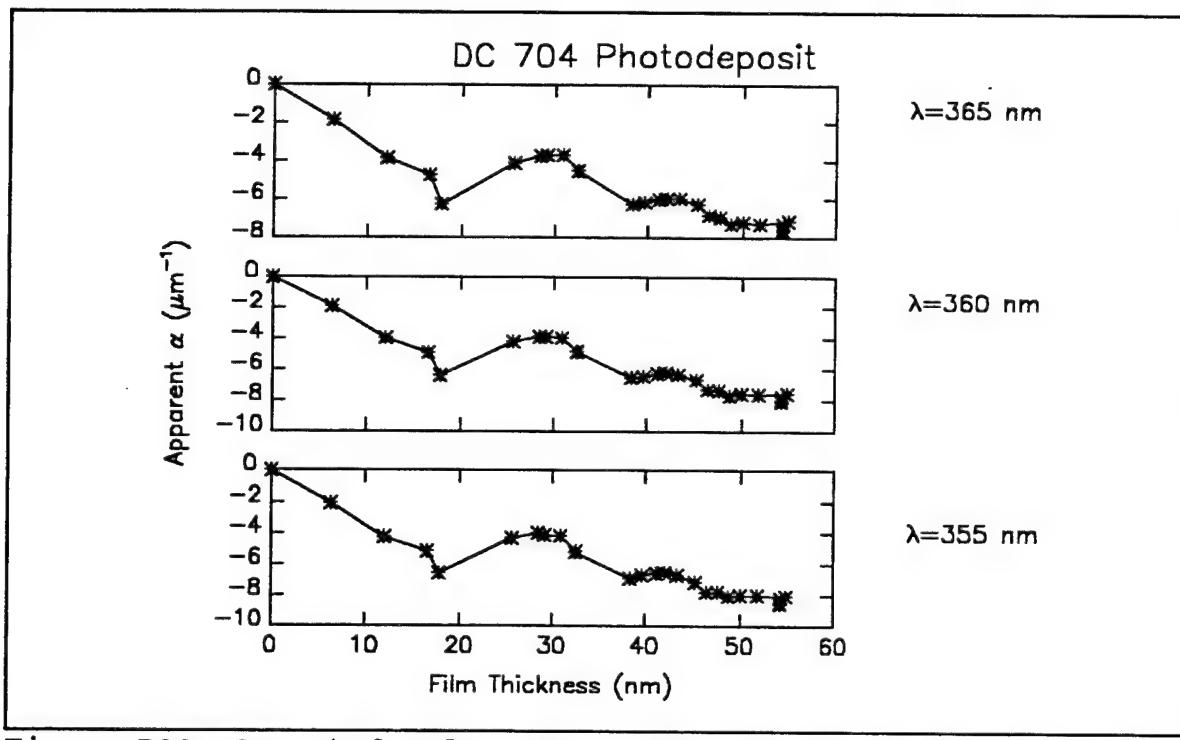


Figure B20w Computed values of α_i for photochemically deposited DC 704 (see eq. B2).

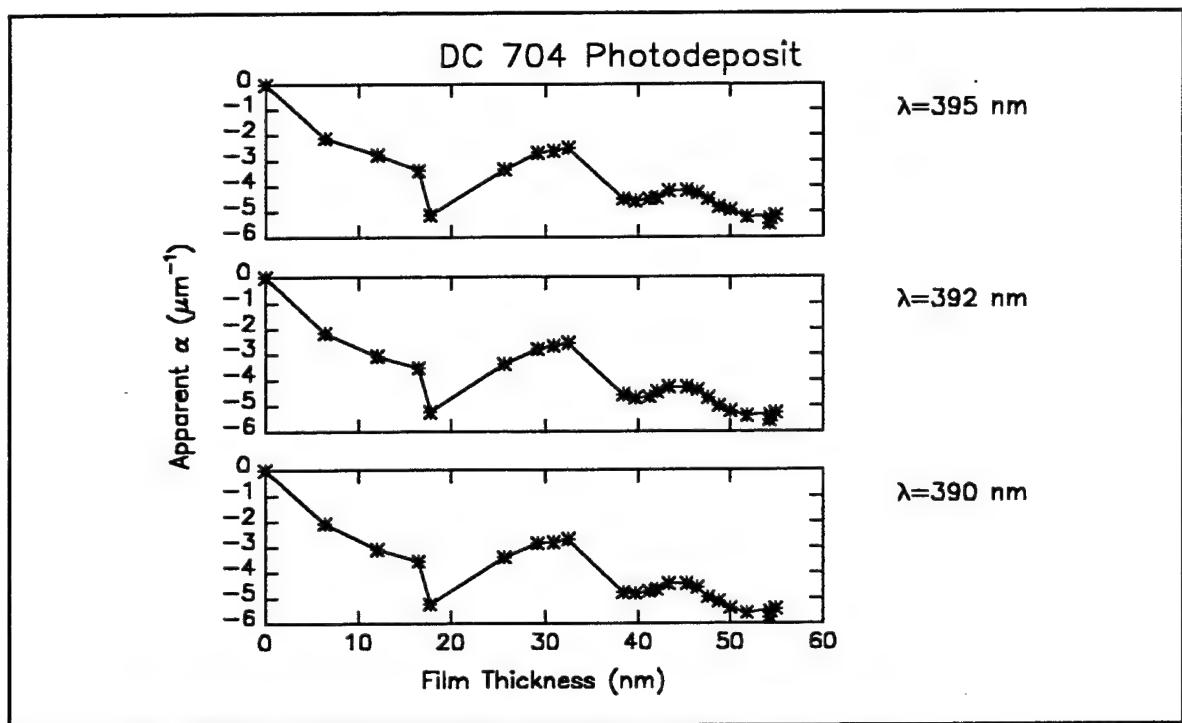


Figure B21a. Computed values of α_i for photochemically deposited films of DC704. Ultraviolet wavelength range

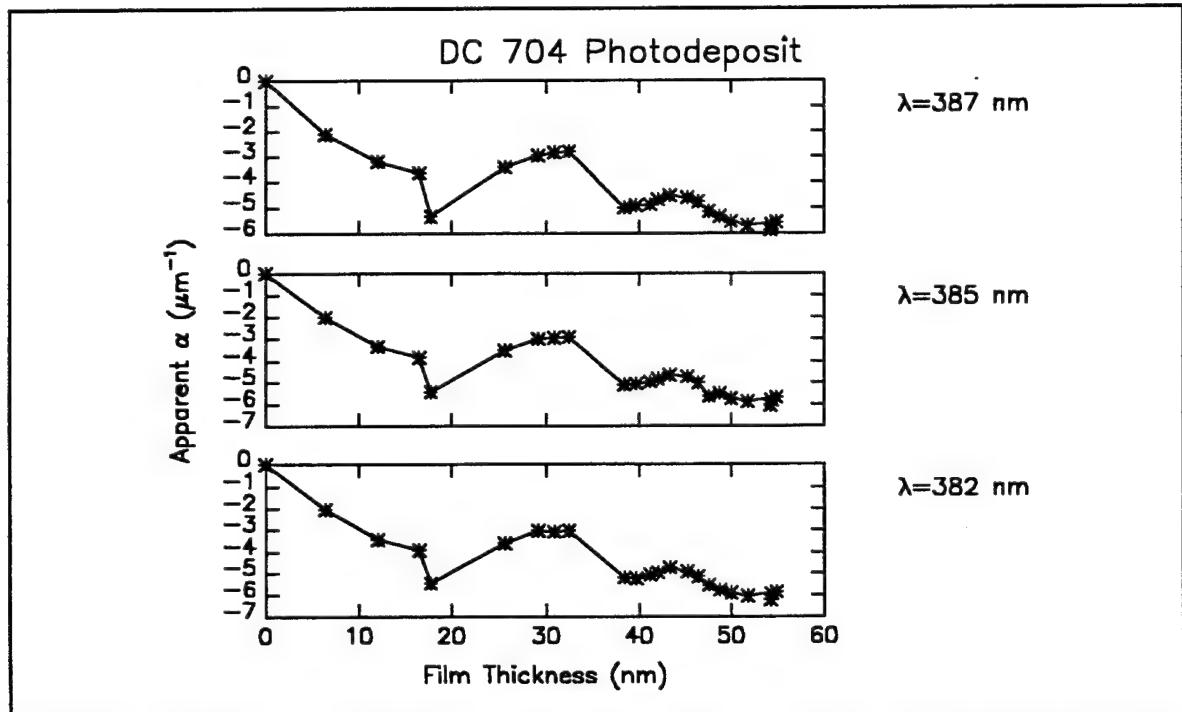


Figure B21b. Computed values of α_i for photochemically deposited films of DC704. Ultraviolet wavelength range

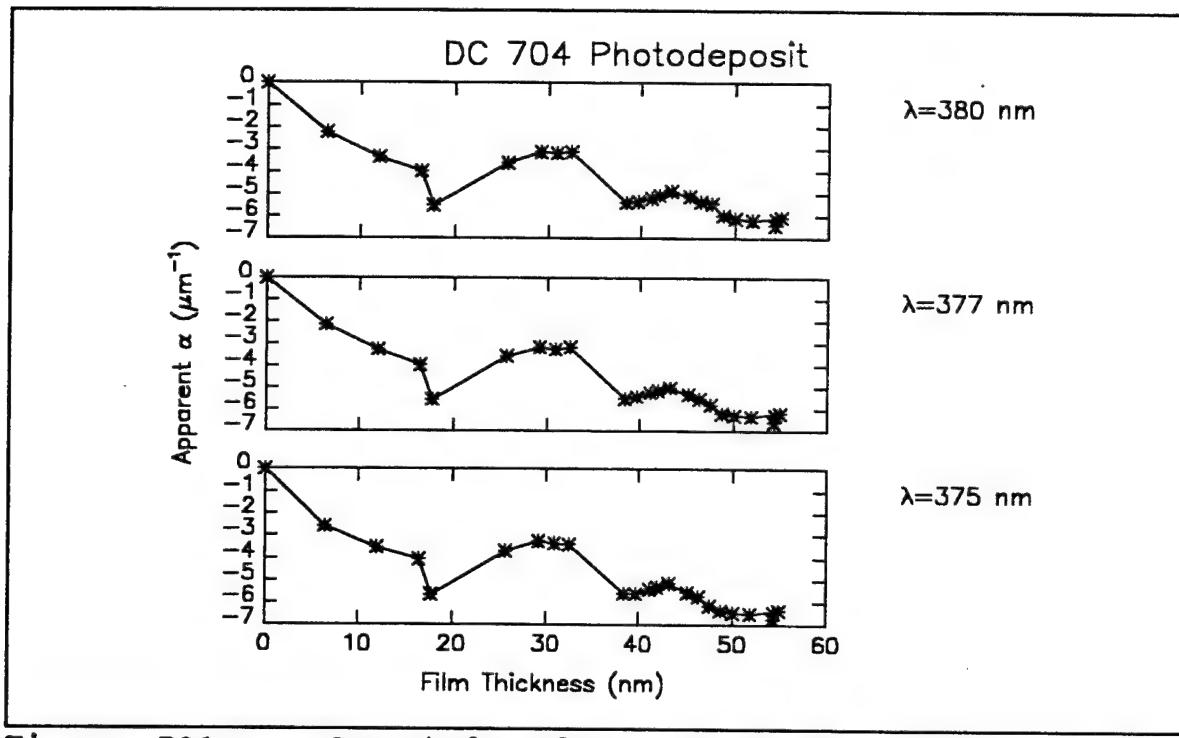


Figure B21c. Computed values of α_j for photochemically deposited films of DC704. Ultraviolet wavelength range

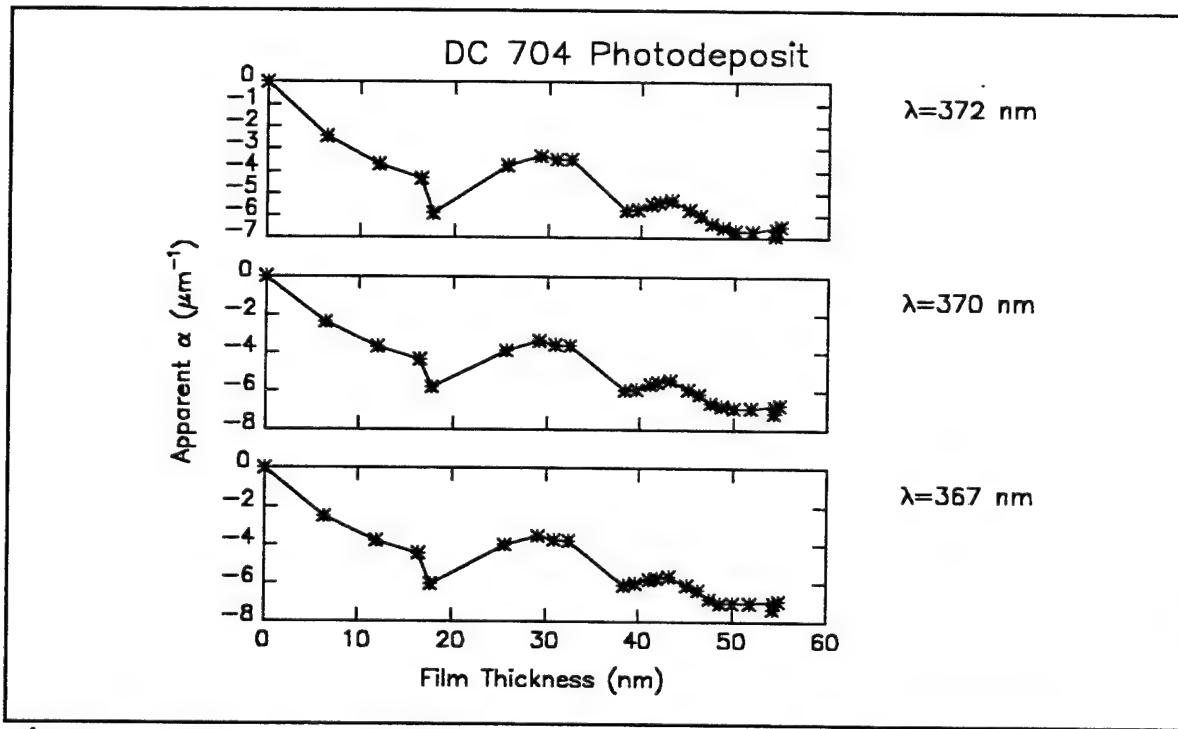


Figure B21d. Computed values of α_j for photochemically deposited films of DC704. Ultraviolet wavelength range

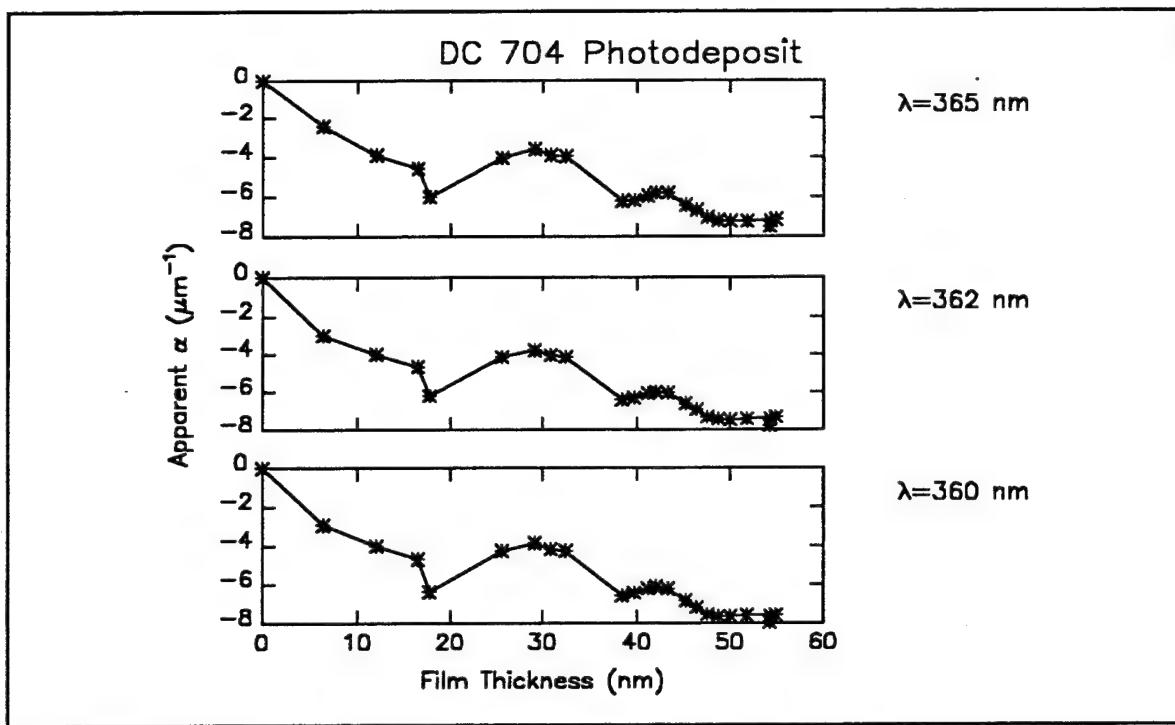


Figure B21e. Computed values of α_j for photochemically deposited films of DC704. Ultraviolet wavelength range

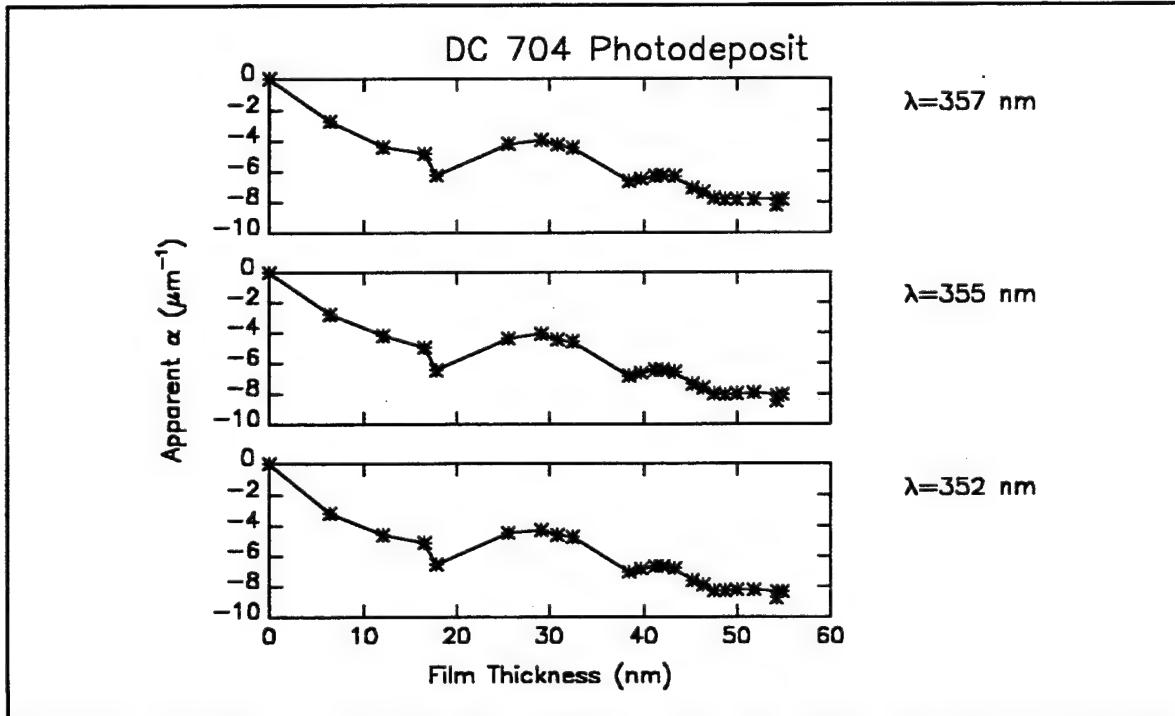


Figure B21f. Computed values of α_j for photochemically deposited films of DC704. Ultraviolet wavelength range

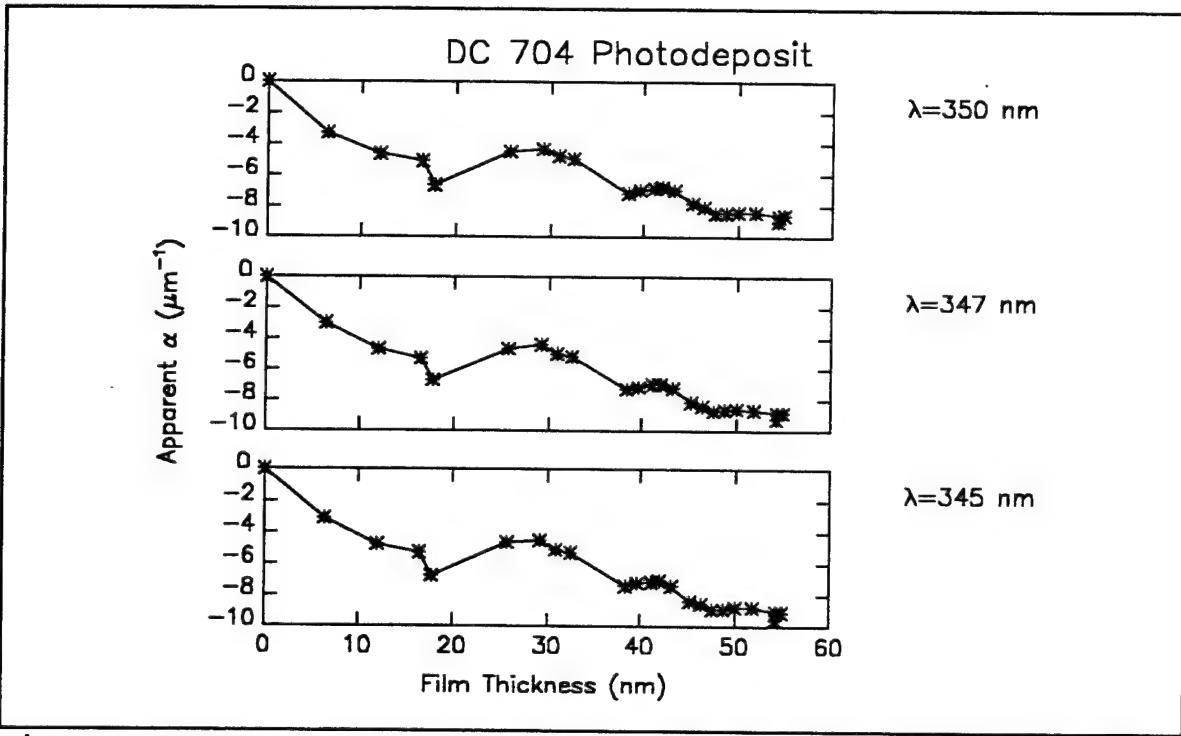


Figure B21g. Computed values of α_j for photochemically deposited films of DC704. Ultraviolet wavelength range

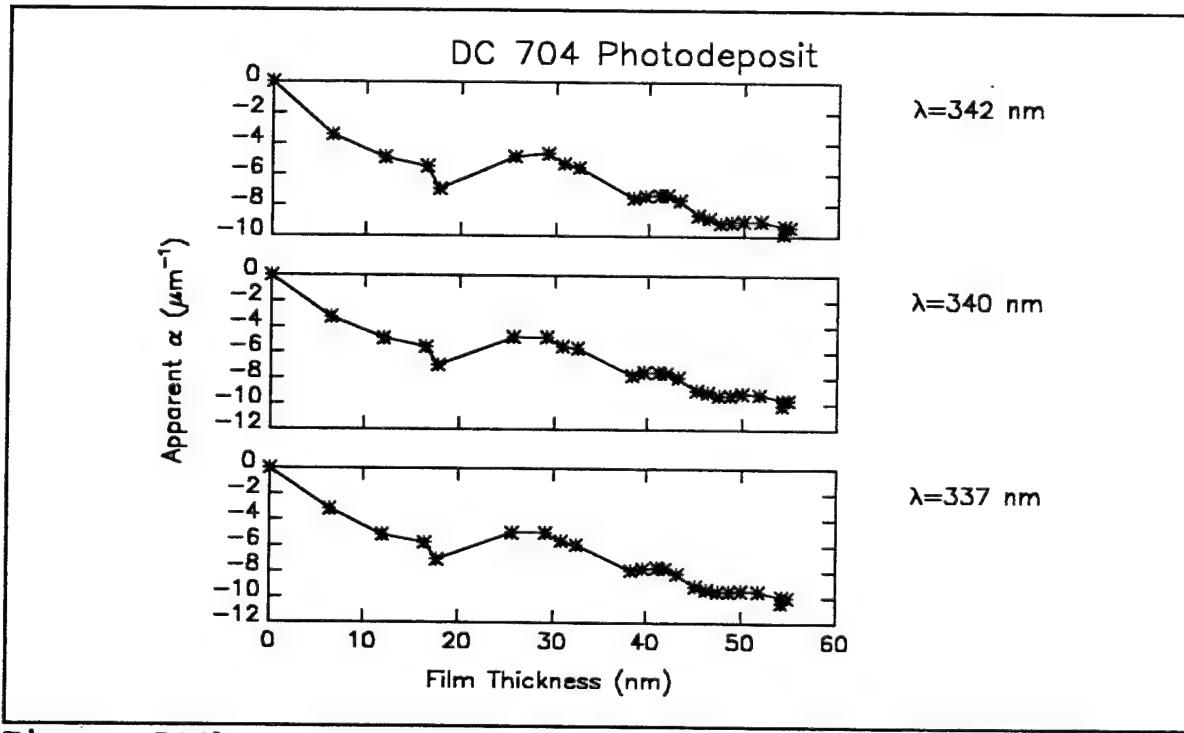


Figure B21h. Computed values of α_j for photochemically deposited films of DC704. Ultraviolet wavelength range

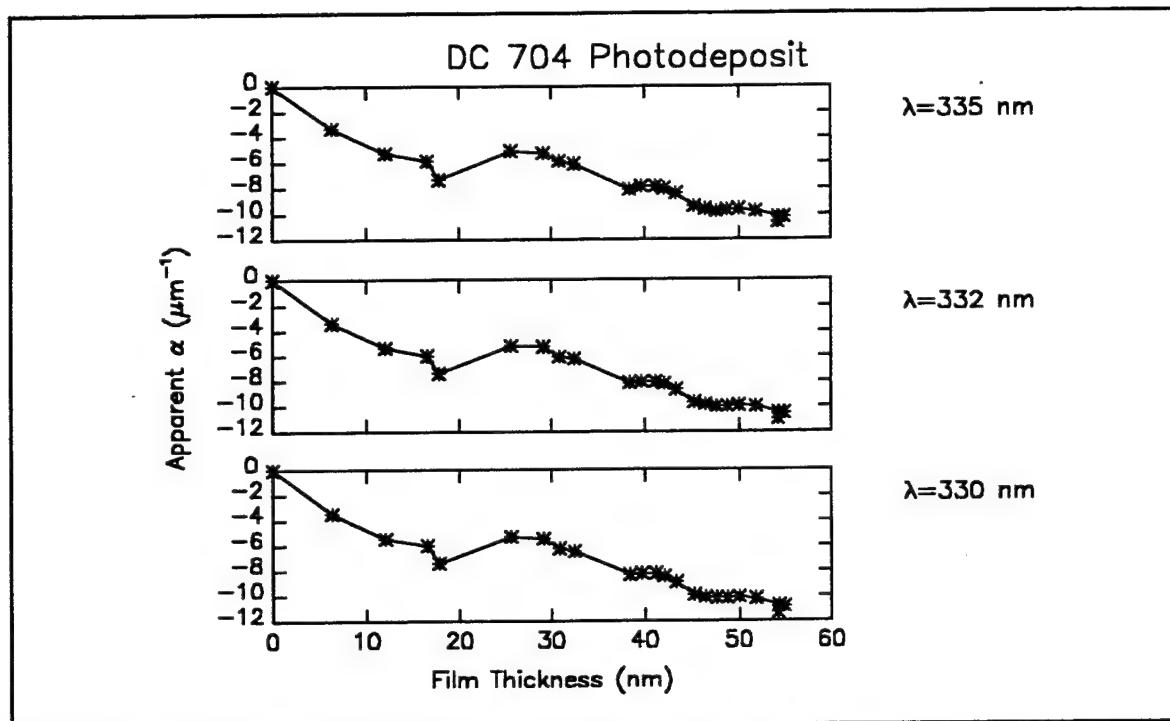


Figure B21i. Computed values of α_i for photochemically deposited films of DC704. Ultraviolet wavelength range

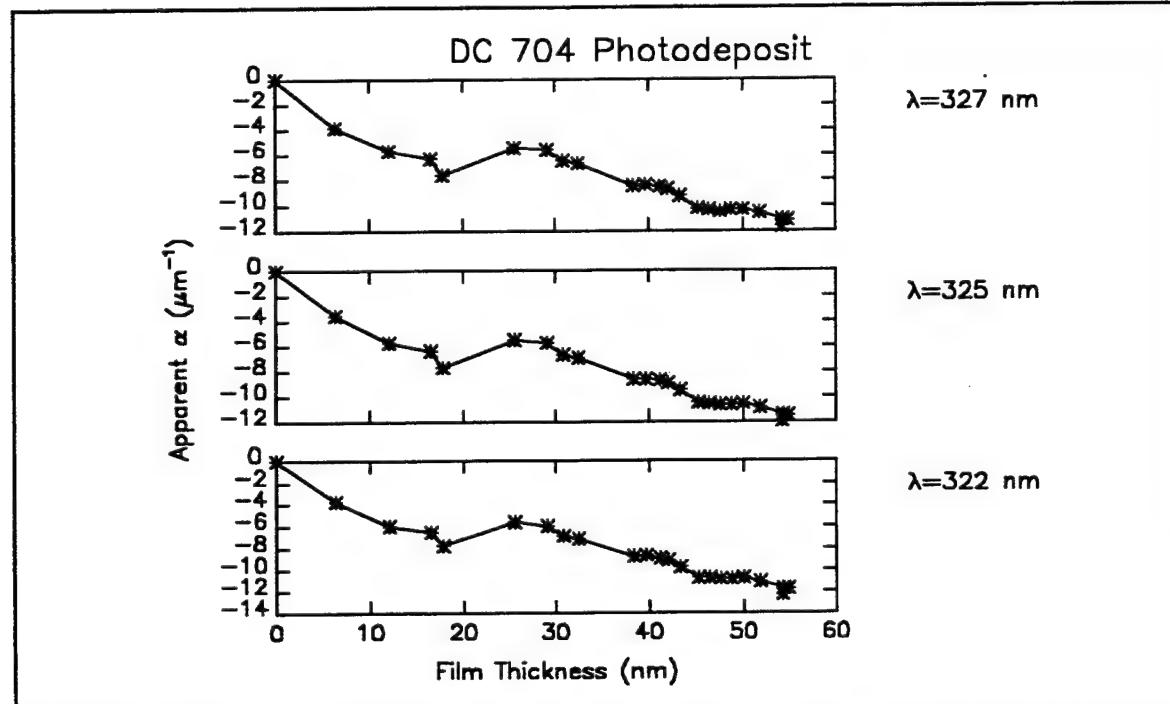


Figure B21j. Computed values of α_i for photochemically deposited films of DC704. Ultraviolet wavelength range

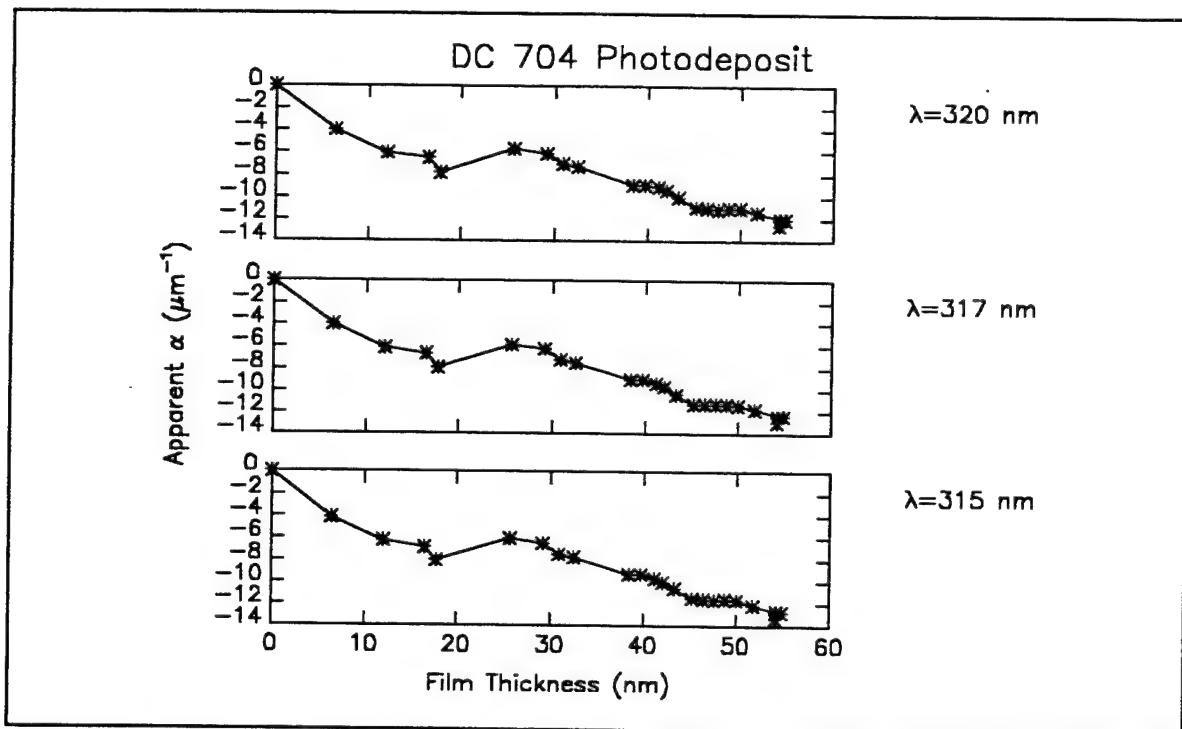


Figure B21k. Computed values of α_j for photochemically deposited films of DC704. Ultraviolet wavelength range

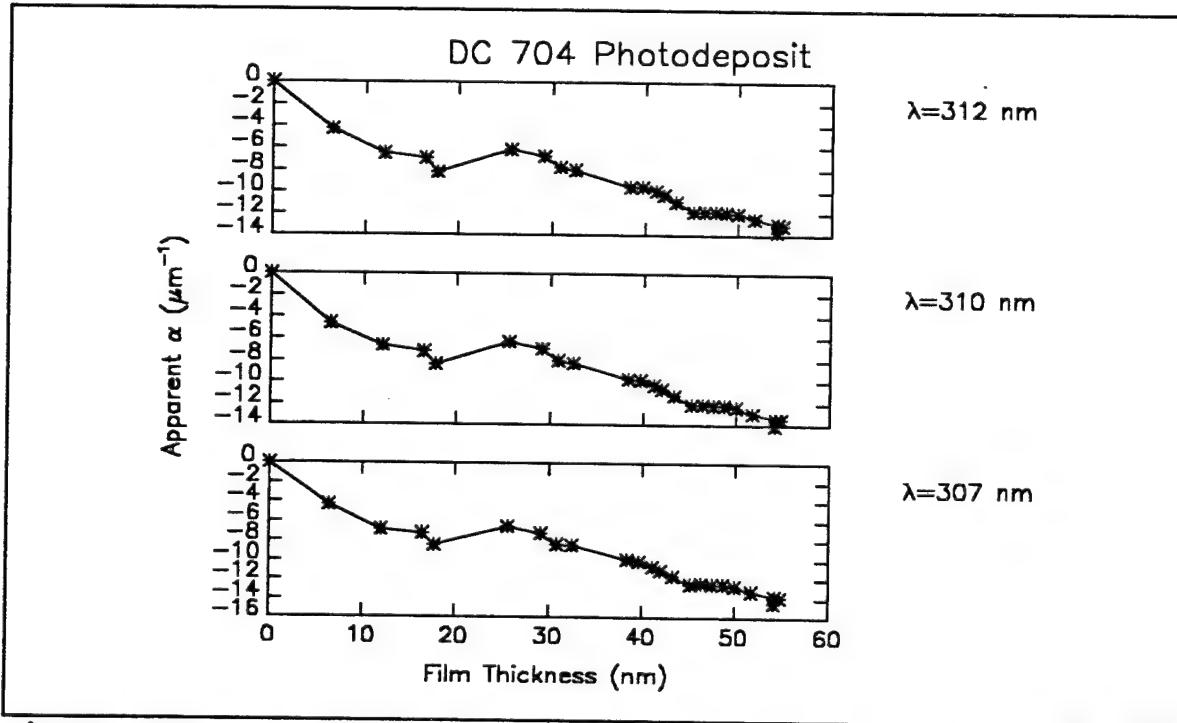


Figure B21l. Computed values of α_j for photochemically deposited films of DC704. Ultraviolet wavelength range

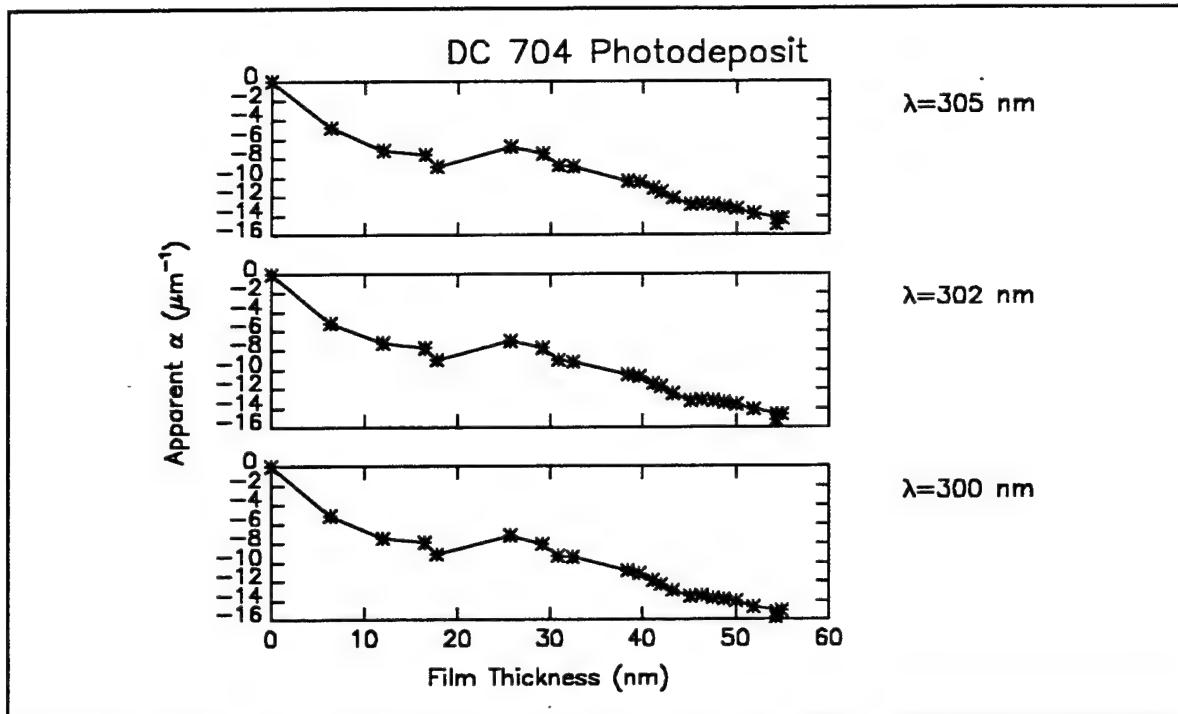


Figure B21m. Computed values of α_j for photochemically deposited films of DC704. Ultraviolet wavelength range

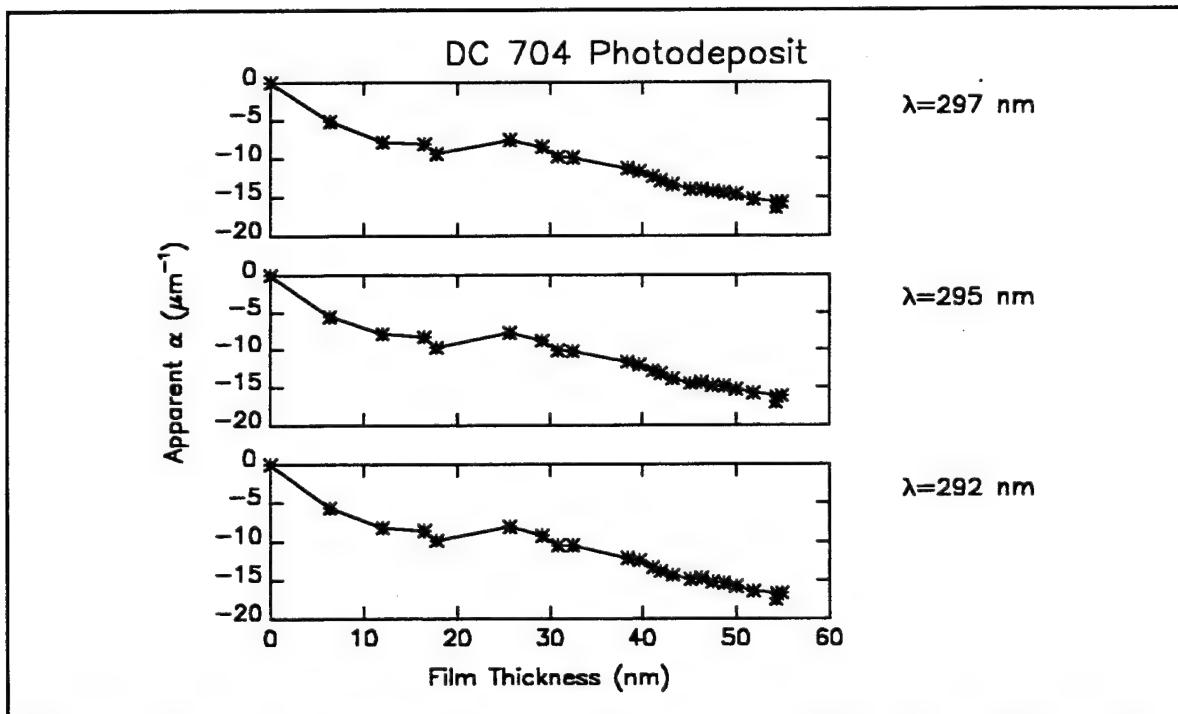


Figure B21n. Computed values of α_j for photochemically deposited films of DC704. Ultraviolet wavelength range

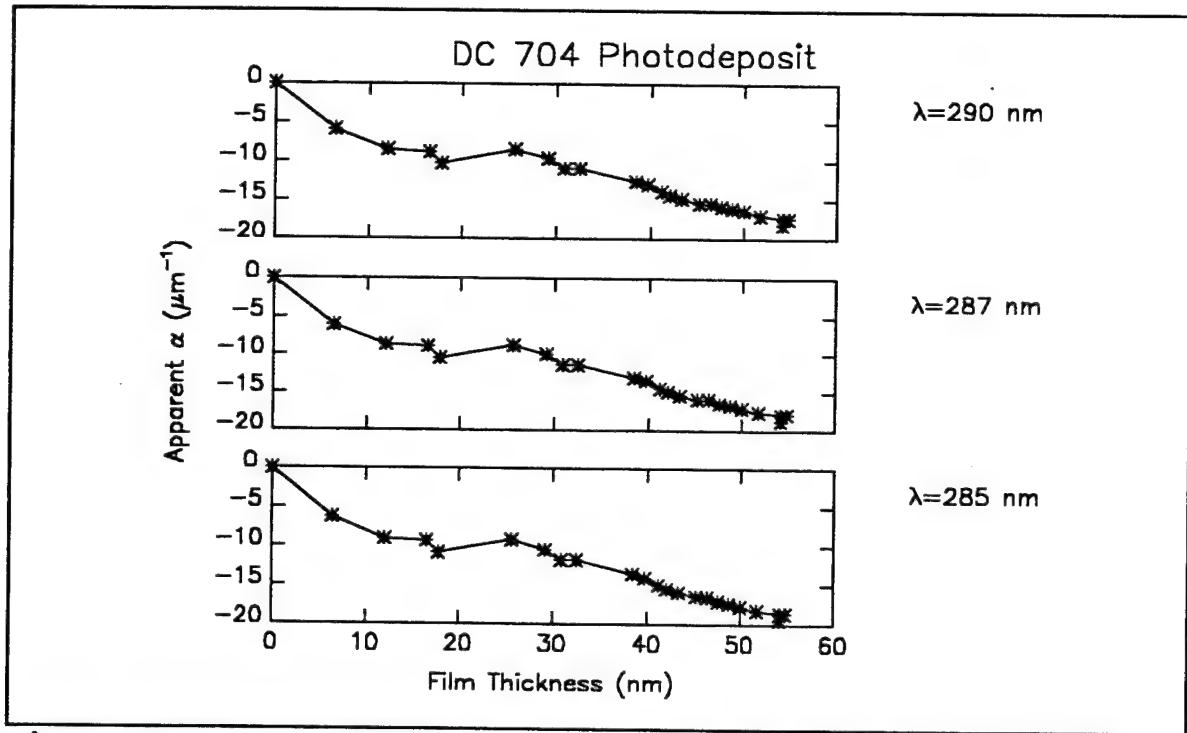


Figure B21o. Computed values of α_j for photochemically deposited films of DC704. Ultraviolet wavelength range

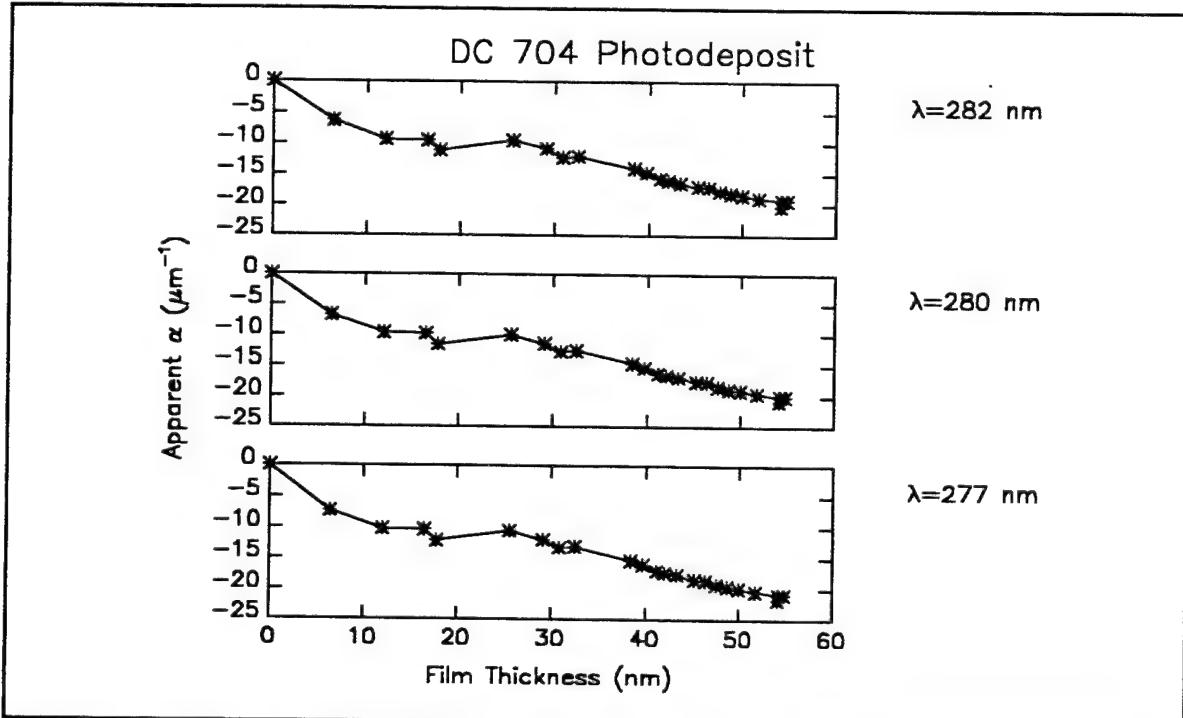


Figure B21p. Computed values of α_j for photochemically deposited films of DC704. Ultraviolet wavelength range

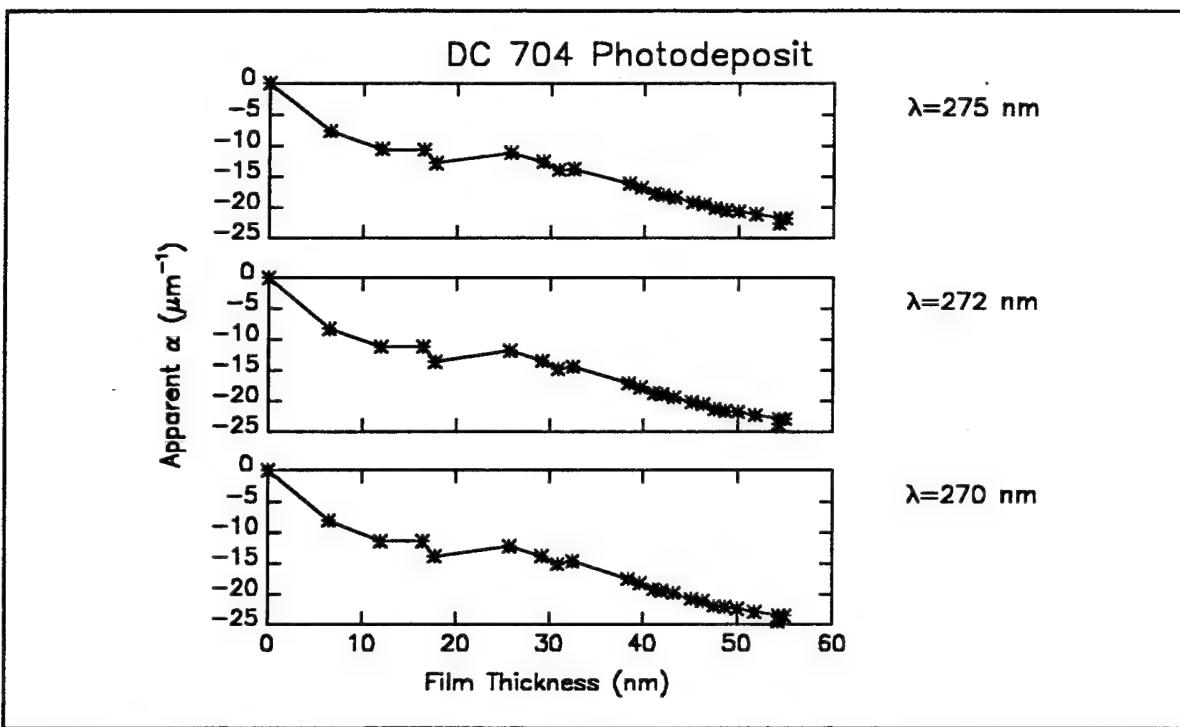


Figure B21q. Computed values of α_j for photochemically deposited films of DC704. Ultraviolet wavelength range

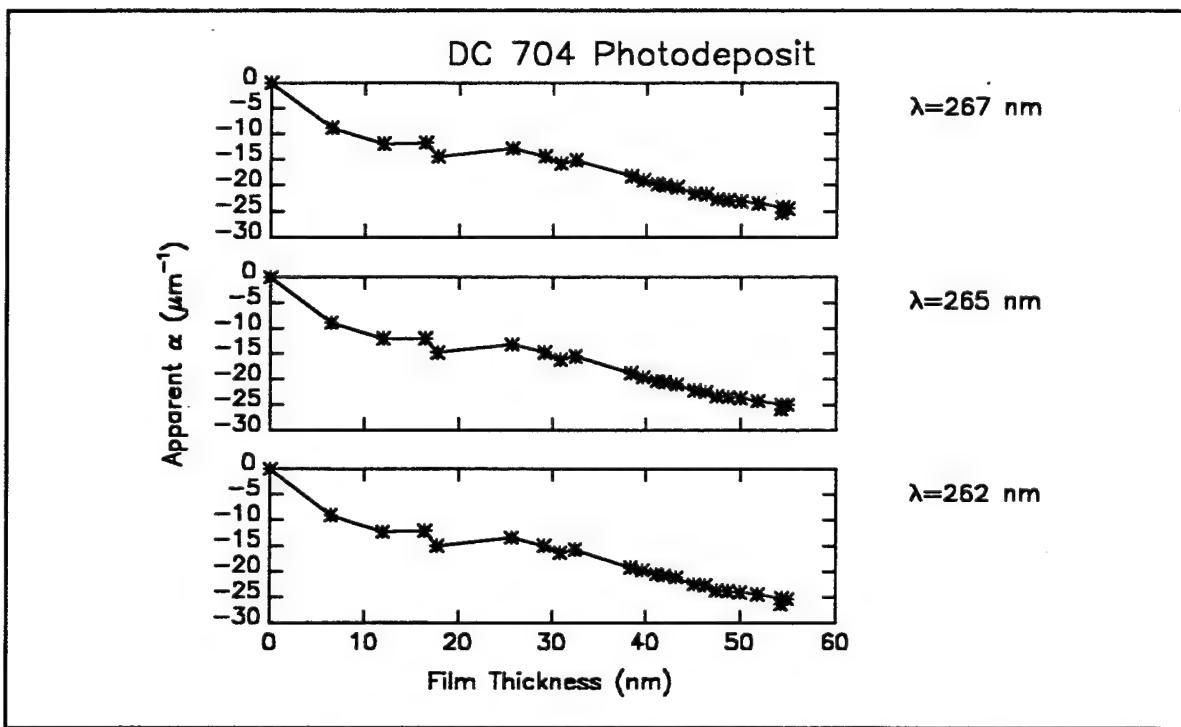


Figure B21r. Computed values of α_j for photochemically deposited films of DC704. Ultraviolet wavelength range

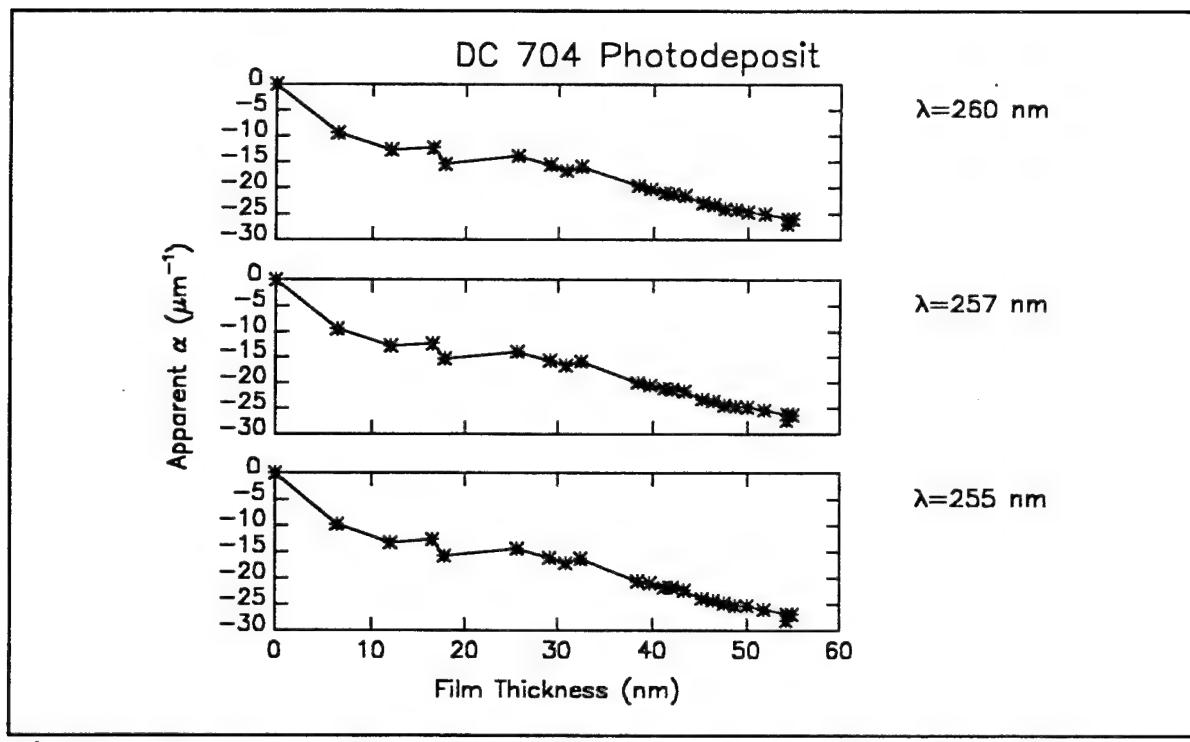


Figure B21s. Computed values of α_j for photochemically deposited films of DC704. Ultraviolet wavelength range

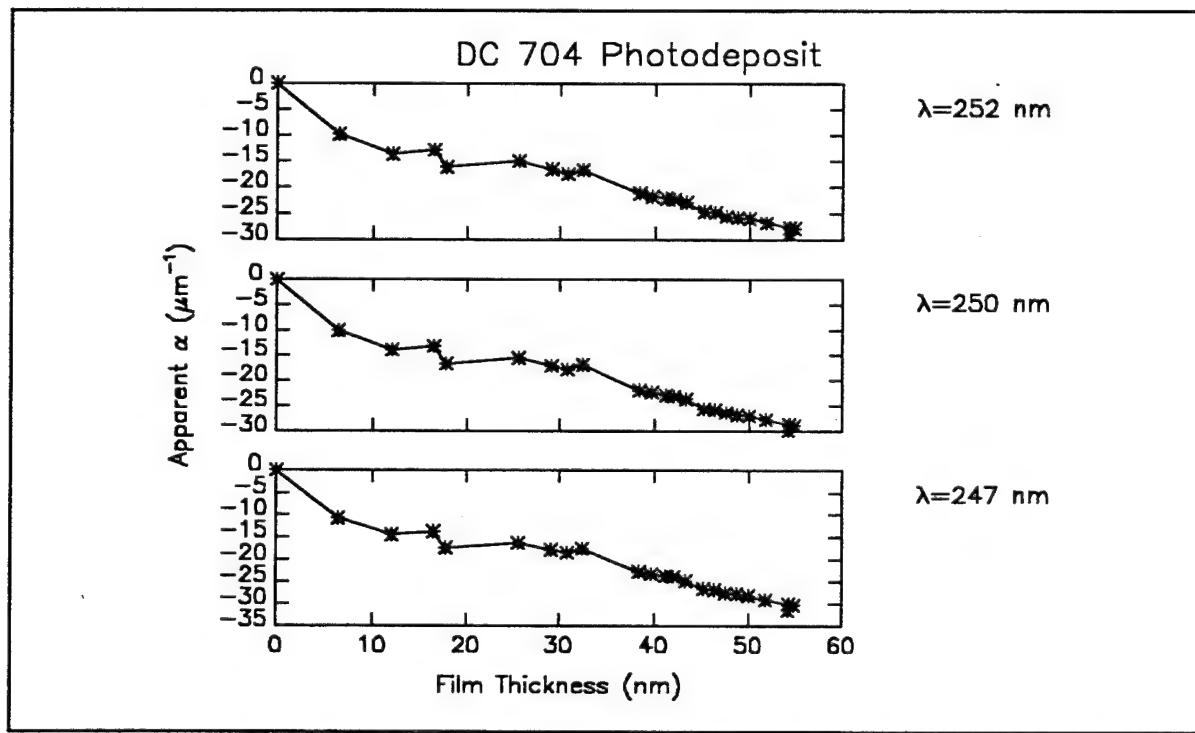


Figure B21t. Computed values of α_j for photochemically deposited films of DC704. Ultraviolet wavelength range

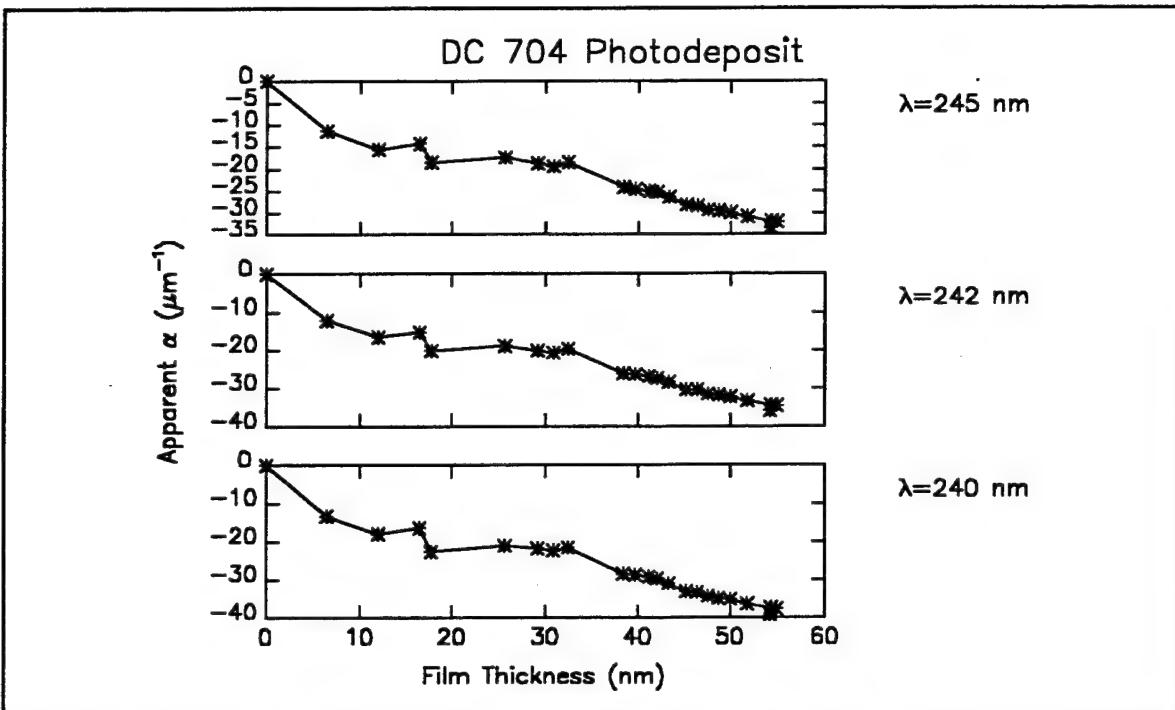


Figure B21u. Computed values of α_j for photochemically deposited films of DC704. Ultraviolet wavelength range

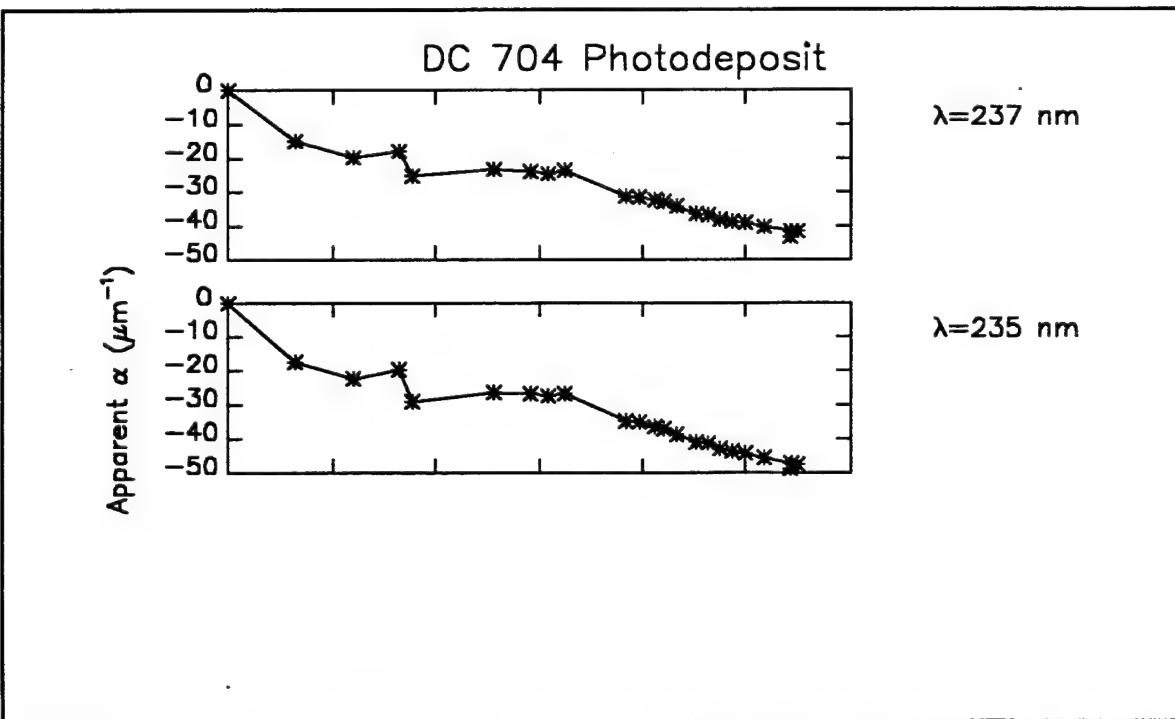


Figure B21v. Computed values of α_j for photochemically deposited films of DC704. Ultraviolet wavelength range

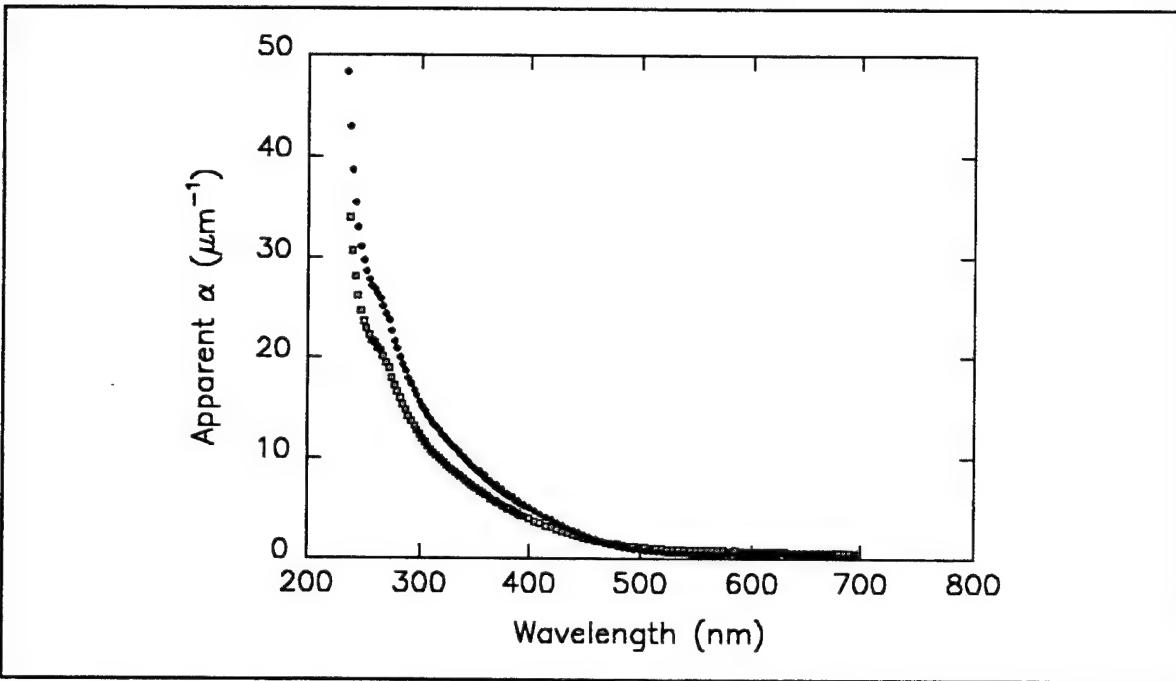


Figure B22. Apparent absorption coefficient (μm^{-1}) of the DC704 photodeposited film, linear plot. Squares, averaging for thick films. Diamonds, Beer's law fit of the entire data set.

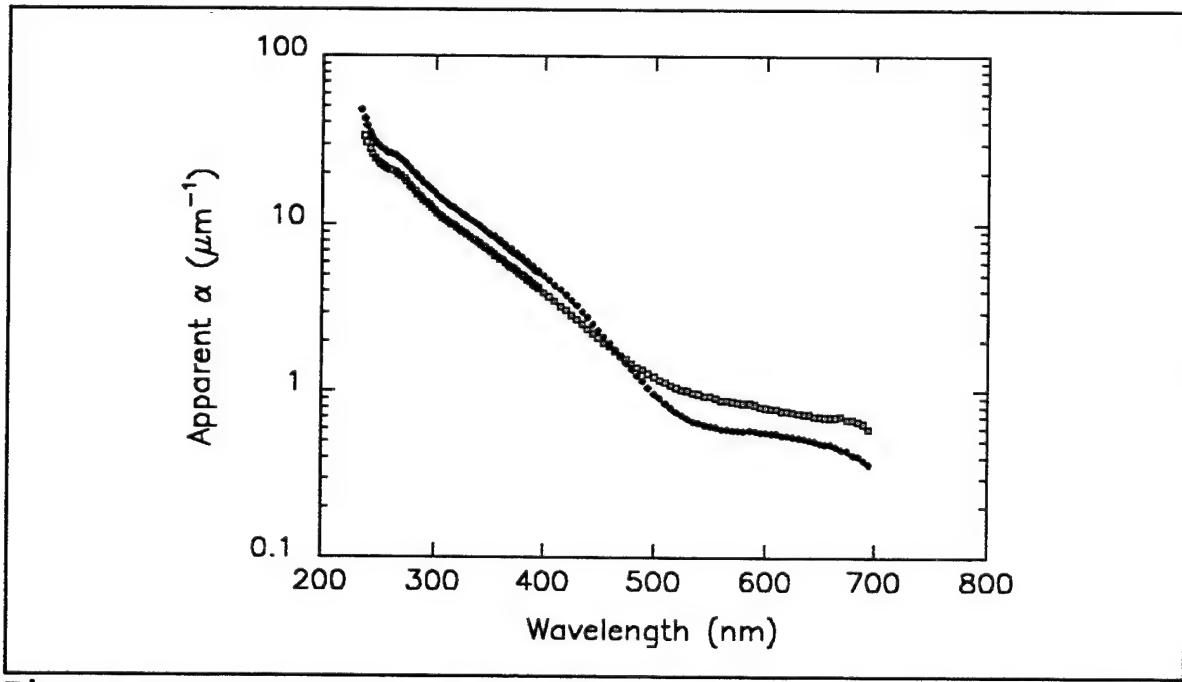


Figure B23. Apparent absorption coefficient (μm^{-1}) of the DC704 photodeposited film, log plot. Squares, averaging for thick films. Diamonds, Beer's law fit of the entire data set.

Appendix C—DEHP

SPECTRA AND FIT RESULTS FOR THE DIOCTYL PHTHALATE PHOTODEPOSIT

This appendix archives the deposition data and transmission spectra measured during a roughly 29 day continuous experiment in which a contaminant film was photochemically deposited from the precursor material dioctyl phthalate (bis diethylhexyl phthalate, or DEHP). This model contaminant, a phthalate ester, serves as an analog for the materials that outgas from polyesters and urethanes, and is a frequently used plasticising agent.

1.0 DEPOSITION DATA AND TRANSMISSION SPECTRA

Figure C1 shows the TQCM data measured during the photochemical deposition of DEHP. The film grew at a rate of about 1.4 Hz/hour (0.06 nm/hour) throughout most of the 700 hour experiment.

The nominal film thickness was calculated assuming a film density equal to the density of the pure precursor material and a TQCM calibration coefficient of 4.43 ng/cm²/Hz. Table C1 shows the nominal thicknesses at which transmission spectra were measured.

Table C1. Nominal film thicknesses, nm, at which transmission spectra were measured.

0.0	4.6	10.1	13.4	14.9	16.6	23.8	25.9	28.7
33.3	37.2	39.4	43.9	45.2	45.6			

The transmission spectra are plotted in Figures C2 through C9. For the most part, the transmission declines monotonically with decreasing wavelength. However, there appears to be some curvature in the visible for the thicker deposits. This curvature becomes apparent in fitting the spectra. (See below.)

2.0 BEER'S LAW FITS

The transmission spectra were fit to the Beer-Lambert absorption law,

$$\log_e(I/I_0) = -\alpha t \quad (C1)$$

where I/I_0 is the transmittance of the film, t is the film thickness, and α is the absorption coefficient of the film. The transmittance of the film was calculated as the ratio of the transmission of the deposit, on the substrate, to the transmission of the clean substrate. Note that the quantity $\log(I/I_0)$ will be called the film absorbance.

Figures C10 and C11 present the results of this analysis. The linear least-squares fits were not constrained to pass through the origin. Figure C12 shows the ratio of the fitted intercept to the absolute value of the largest absorbance measured. The large values of this ratio are a reflection of the curvature in the spectra and in the Beer's law plots in the mid-visible range.

The actual fits are shown in Figure C13 for the visible wavelengths, and C14 for the ultraviolet wavelengths.* Tables C2 and C3 present the results of the visible and ultraviolet fits, respectively.

3.0 CONSTRAINED FITS

Because data for some of the wavelengths studied show curvature of the absorbance vs. thickness plots, a second approach was used to extract an apparent absorption coefficient from the data. In this case, the "Beer's law plot" is constrained to pass through the origin, by calculating an apparent α as

$$\alpha = \langle \alpha_j \rangle = \frac{1}{j_f - j_i + 1} \sum_{j=j_i}^{j=j_f} \frac{\log_e[I(t_j)/I_0]}{t_j} \quad (C2)$$

where I/I_0 is the transmittance of the film, t_j is the film thickness for the j th measurement, and α is the absorption coefficient of the film. The transmittance of the film was calculated as the ratio of the transmission of the deposit, on the substrate, to the transmission of the clean substrate.

Figures C15 and C16 present the results of this analysis, where the average was performed for thicknesses greater than 14 nm in the visible and greater than 40 nm in the ultraviolet. The constrained data (α_j) are shown in Figure C17 for the visible wavelengths, and C18 for the ultraviolet wavelengths. Tables C4 and C5 present the results of the visible and ultraviolet fits, respectively.

* Note that the plots show the absorption coefficient as a negative number, which is opposite to the sign convention shown in equation C1.

4.0 COMPARISON OF THE FITS

Figures C20 and C21 provide comparisons of the apparent absorption coefficients obtained from the two fitting approaches. They are everywhere in agreement to within better than a factor of two.

Table C2. Beer's law fit results for the DEHP photodeposit, visible wavelength range.

Wavelength (nm)	Apparent α (μm^{-1})	Intercept (see plots)
695.0	1.05	0.004
690.0	1.04	0.003
685.0	1.03	0.003
680.0	1.03	0.001
675.0	1.02	0.002
670.0	1.00	0.002
665.0	0.99	0.002
660.0	0.98	0.001
655.0	0.97	0.001
650.0	0.95	0.001
645.0	0.93	0.000
640.0	0.92	0.000
635.0	0.91	0.000
630.0	0.89	-0.001
625.0	0.88	-0.001
620.0	0.86	-0.001
615.0	0.83	-0.002
610.0	0.82	-0.002
605.0	0.81	-0.002
600.0	0.80	-0.003
595.0	0.79	-0.003
590.0	0.77	-0.004

Table C2, continued.

Wavelength (nm)	Apparent α (μm^{-1})	Intercept (see plots)
585.0	0.77	-0.003
580.0	0.75	-0.004
575.0	0.73	-0.004
570.0	0.73	-0.005
565.0	0.72	-0.005
560.0	0.71	-0.006
555.0	0.70	-0.006
550.0	0.68	-0.006
545.0	0.68	-0.007
540.0	0.67	-0.007
535.0	0.66	-0.008
530.0	0.67	-0.008
525.0	0.67	-0.008
520.0	0.69	-0.008
515.0	0.69	-0.008
510.0	0.70	-0.009
505.0	0.72	-0.009
500.1	0.74	-0.009
495.0	0.77	-0.009
490.0	0.81	-0.009
485.0	0.84	-0.009
480.1	0.90	-0.009
475.0	0.95	-0.009
470.0	1.02	-0.008
465.0	1.10	-0.008
460.0	1.19	-0.008
455.0	1.29	-0.007

Table C2, continued.

Wavelength (nm)	Apparent α (μm^{-1})	Intercept (see plots)
450.0	1.41	-0.006
445.0	1.53	-0.006
440.0	1.68	-0.004
435.0	1.85	-0.003
430.0	2.03	-0.002
425.0	2.23	0.000
420.0	2.46	0.001
415.0	2.71	0.003
410.0	2.98	0.005
405.0	3.27	0.007
400.0	3.57	0.010
395.0	3.92	0.011
390.0	4.29	0.014
385.0	4.72	0.018
380.0	5.14	0.020
375.0	5.60	0.024
370.0	6.08	0.027
365.0	6.60	0.030
360.0	7.14	0.034
355.0	7.69	0.038

Table C4. Beer's law fit results for the DEHP photodeposit, ultraviolet wavelength range.

Wavelength (μm^{-1})	Apparent α	Intercept (see plots)
395.0	3.75	0.007
392.5	3.93	0.009

Table C3, continued

Wavelength (μm^{-1})	Apparent α	Intercept (see plots)
390.0	4.08	0.010
387.5	4.28	0.012
385.0	4.52	0.014
382.5	4.72	0.015
380.0	4.92	0.015
377.5	5.19	0.016
375.0	5.38	0.018
372.5	5.66	0.022
370.0	5.89	0.021
367.5	6.14	0.024
365.0	6.45	0.029
362.5	6.70	0.030
360.0	6.99	0.032
357.5	7.24	0.033
355.0	7.54	0.037
352.5	7.81	0.038
350.0	8.02	0.037
347.5	8.37	0.039
345.0	8.76	0.044
342.5	9.09	0.046
340.0	9.42	0.047
337.5	9.75	0.047
335.0	10.23	0.055
332.5	10.62	0.057
330.0	10.95	0.057
327.5	11.29	0.058
325.0	11.66	0.061

Table C3, continued

Wavelength (μm^{-1})	Apparent α	Intercept (see plots)
322.5	12.08	0.065
320.0	12.48	0.067
317.5	12.88	0.070
315.0	13.35	0.074
312.5	13.76	0.075
310.0	14.16	0.074
307.5	14.58	0.074
305.0	15.08	0.078
302.5	15.64	0.085
300.0	16.14	0.088
297.5	16.71	0.091
295.0	17.35	0.095
292.5	18.02	0.097
290.0	18.74	0.100
287.5	19.50	0.100
285.0	20.29	0.100
282.5	21.14	0.105
280.0	21.86	0.110
277.5	22.68	0.118
275.0	23.56	0.128
272.5	24.24	0.132
270.0	24.85	0.134
267.5	25.57	0.138
265.0	26.35	0.142
262.5	27.20	0.147
260.0	28.14	0.154
257.5	29.21	0.161

Table C3, continued

Wavelength (μm^{-1})	Apparent α	Intercept (see plots)
255.0	30.23	0.160
252.5	31.42	0.161
250.0	32.78	0.164
247.5	34.31	0.169
245.0	35.98	0.174
242.5	37.61	0.177
240.0	39.28	0.177
237.5	41.18	0.183

Table C4. Apparent absorption coefficients from the constrained fits, visible wavelengths.

Wavelength (nm)	Apparent α (μm^{-1})
695	0.93
690	0.96
685	0.95
680	1.01
675	0.97
670	0.96
665	0.94
660	0.97
655	0.97
650	0.95
645	0.97
640	0.99
635	0.97
630	0.97

Table C4, continued

Wavelength (nm)	Apparent α (μm^{-1})
625	0.97
620	0.97
615	0.96
610	0.97
605	0.96
600	0.97
595	0.97
590	0.98
585	0.97
580	0.99
575	0.98
570	1.00
565	1.00
560	1.02
555	1.02
550	1.02
545	1.05
540	1.03
535	1.07
530	1.09
525	1.10
520	1.12
515	1.14
510	1.17
505	1.18
500	1.22
495	1.25

Table C4, continued

Wavelength (nm)	Apparent α (μm^{-1})
490	1.30
485	1.31
480	1.37
475	1.42
470	1.47
465	1.53
460	1.63
455	1.69
450	1.78
445	1.88
440	1.97
435	2.10
430	2.22
425	2.35
420	2.53
415	2.68
410	2.87
405	3.08
400	3.26
395	3.54
390	3.76
385	4.05
380	4.34
375	4.66
370	4.99
365	5.36
360	5.73

Table C4, continued

Wavelength (nm)	Apparent α (μm^{-1})
355	6.12

Table C5. Apparent absorption coefficients from the constrained fits, ultraviolet wavelengths.

Wavelength (nm)	Apparent α (μm^{-1})
395.0	3.49
392.5	3.56
390.0	3.68
387.5	3.83
385.0	3.95
382.5	4.12
380.0	4.32
377.5	4.50
375.0	4.62
372.5	4.70
370.0	5.01
367.5	5.14
365.0	5.18
362.5	5.39
360.0	5.61
357.5	5.79
355.0	5.89
352.5	6.07
350.0	6.41
347.5	6.67
345.0	6.81

Table C5, continued

Wavelength (nm)	Apparent α (μm^{-1})
342.5	7.10
340.0	7.36
337.5	7.67
335.0	7.79
332.5	8.10
330.0	8.51
327.5	8.80
325.0	8.94
322.5	9.15
320.0	9.48
317.5	9.80
315.0	10.09
312.5	10.45
310.0	10.93
307.5	11.34
305.0	11.64
302.5	11.91
300.0	12.28
297.5	12.65
295.0	13.09
292.5	13.70
290.0	14.34
287.5	15.10
285.0	15.83
282.5	16.45
280.0	16.97
277.5	17.44

Table C5, continued

Wavelength (nm)	Apparent α (μm^{-1})
275.0	17.90
272.5	18.45
270.0	18.88
267.5	19.39
265.0	19.97
262.5	20.65
260.0	21.35
257.5	22.08
255.0	23.16
252.5	24.29
250.0	25.43
247.5	26.72
245.0	28.19
242.5	29.64
240.0	31.28
237.5	32.93

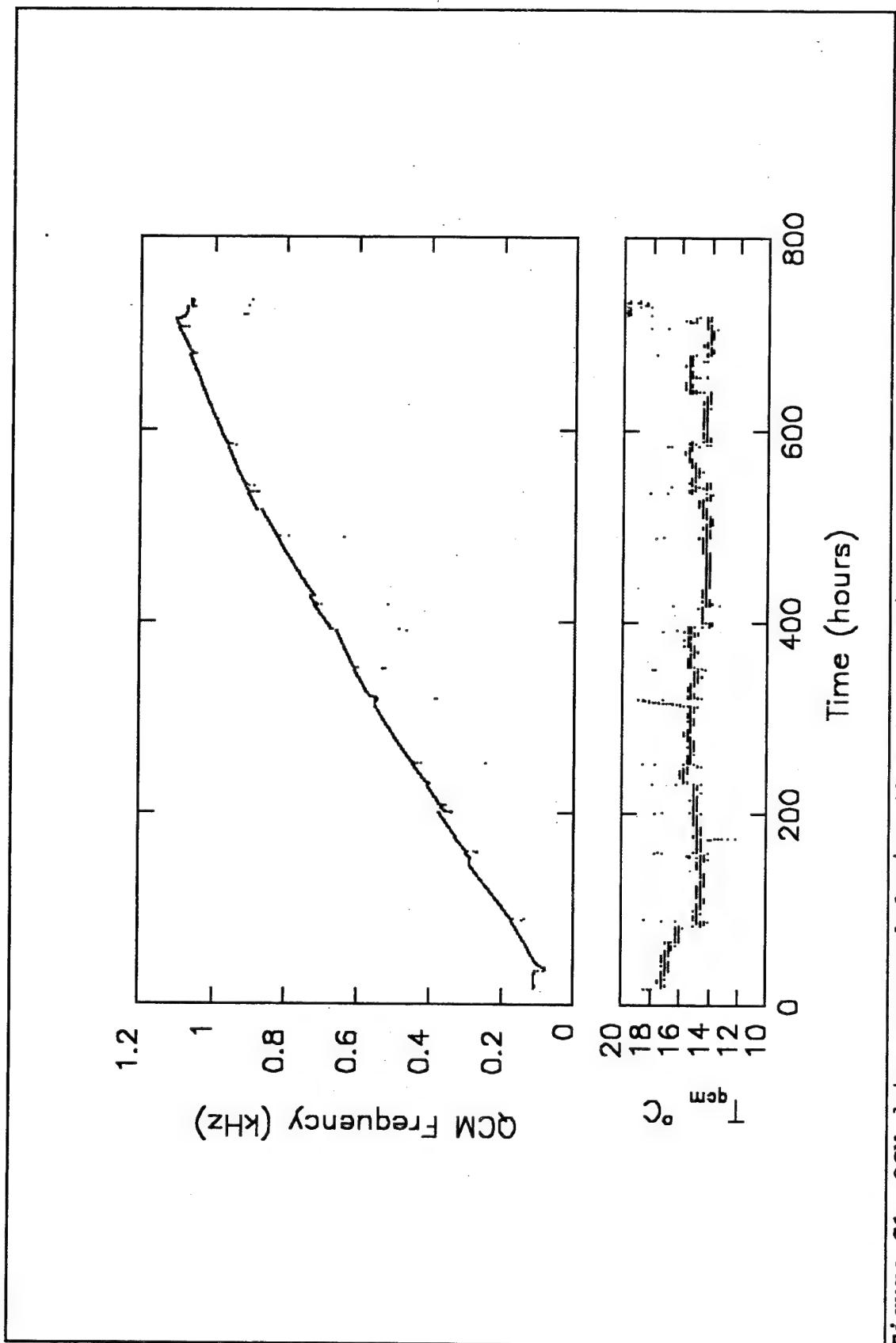


Figure C1 QCM data measured during the photochemical deposition of dioctylphthalate.

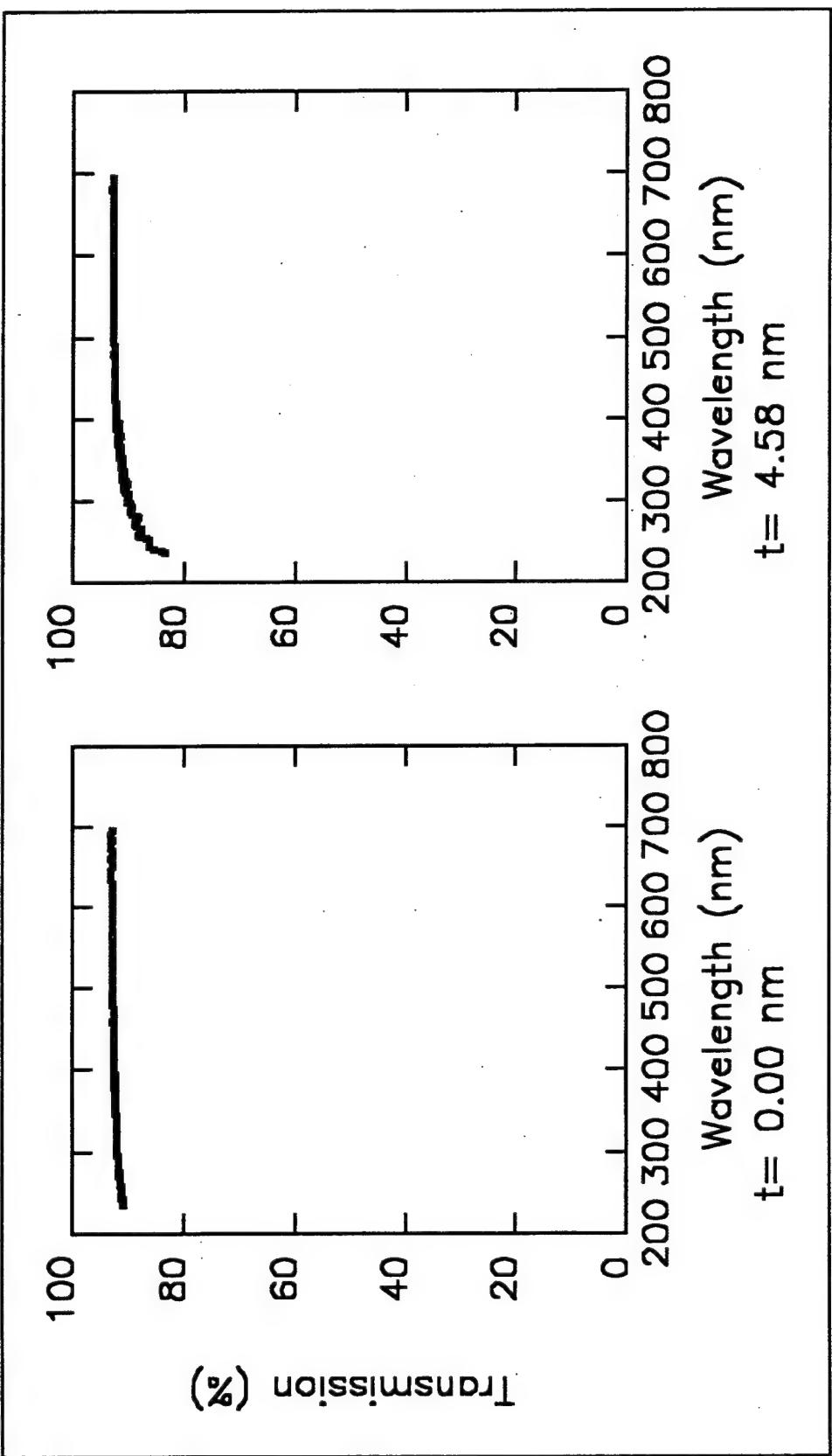


Figure C2 Transmission spectra measured during photodeposition of DEHP.

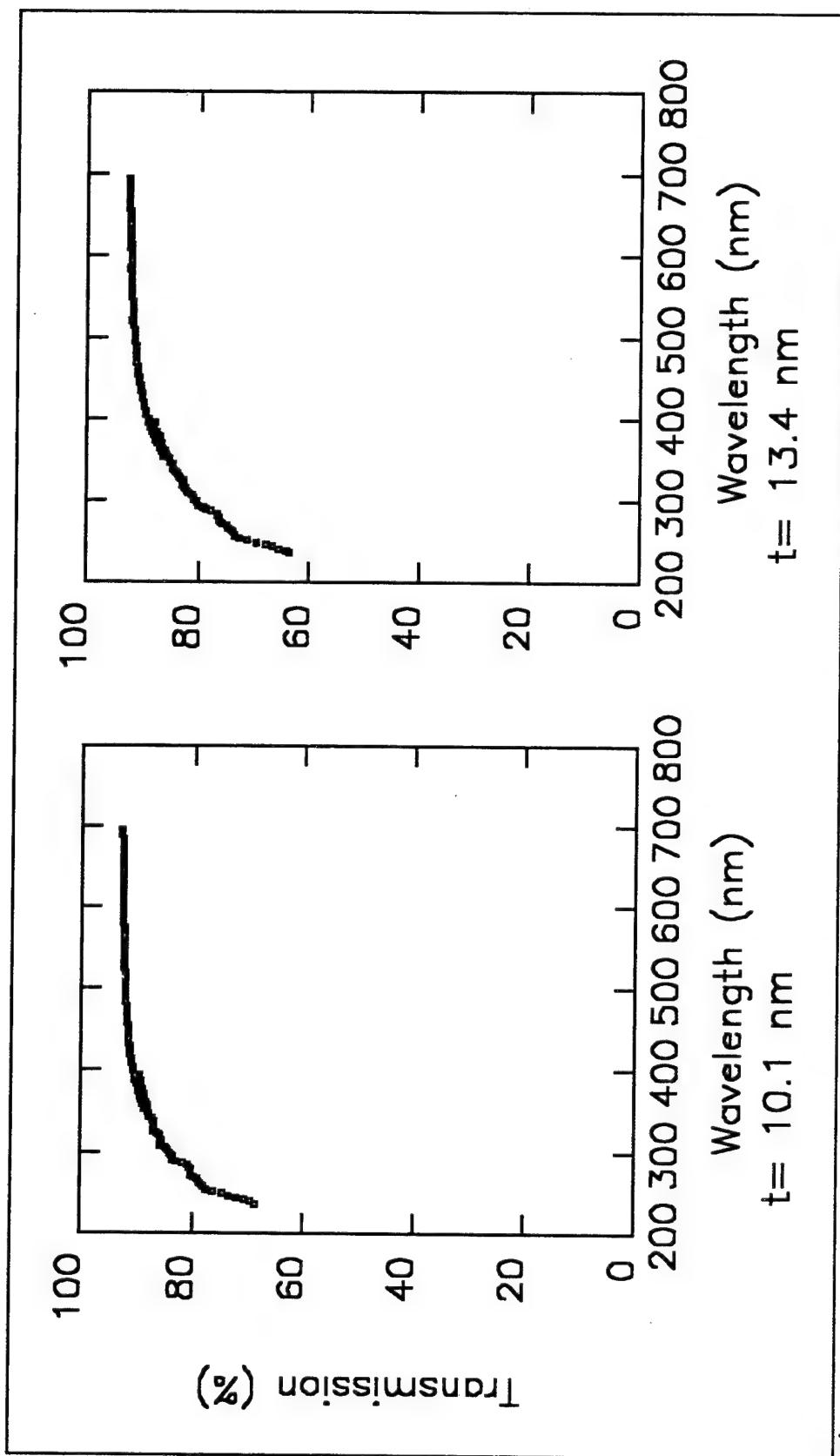


Figure C3 Transmission spectra measured during photodeposition of DEHP.

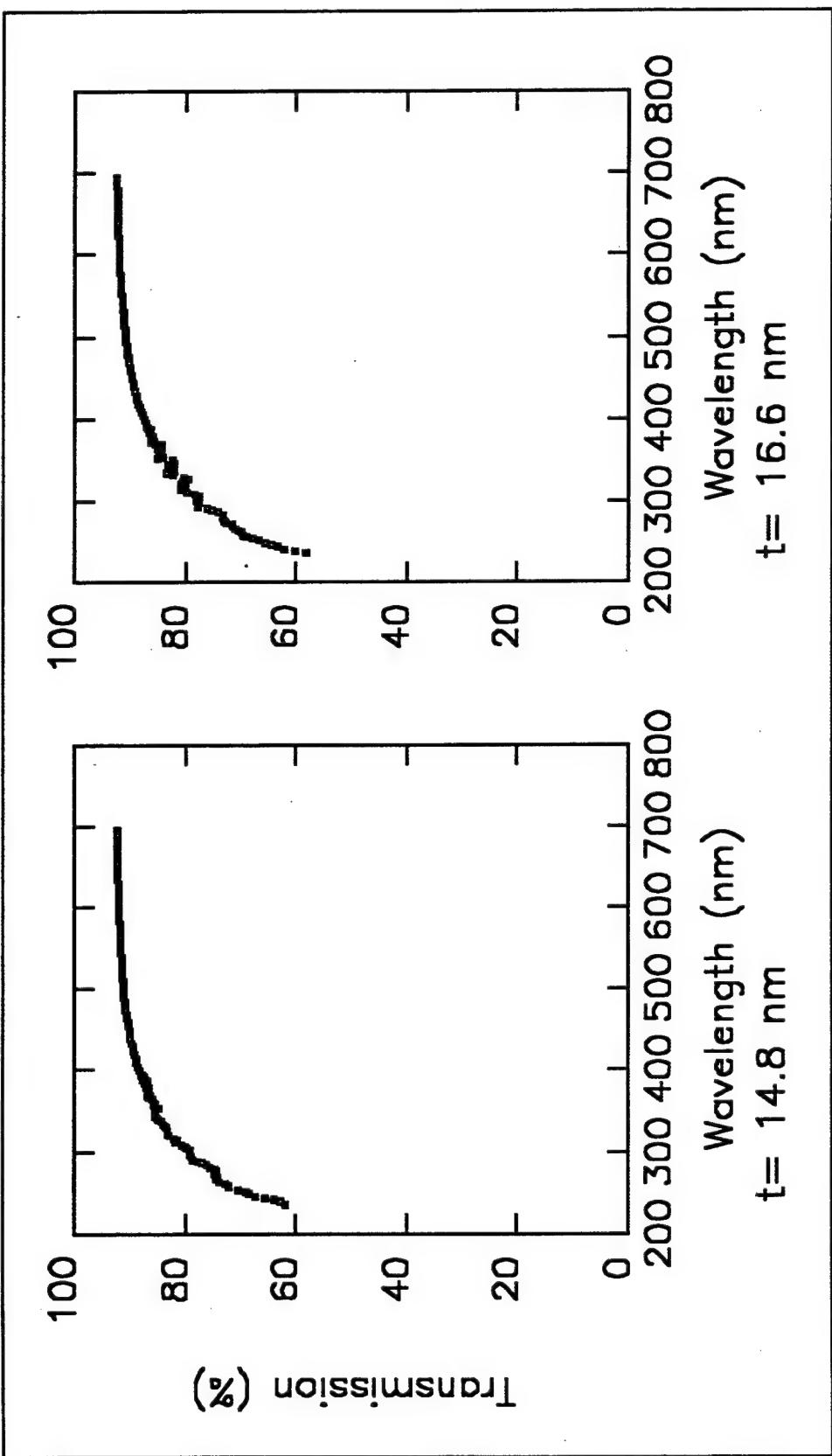


Figure C4 Transmission spectra measured during photodeposition of DEHP.

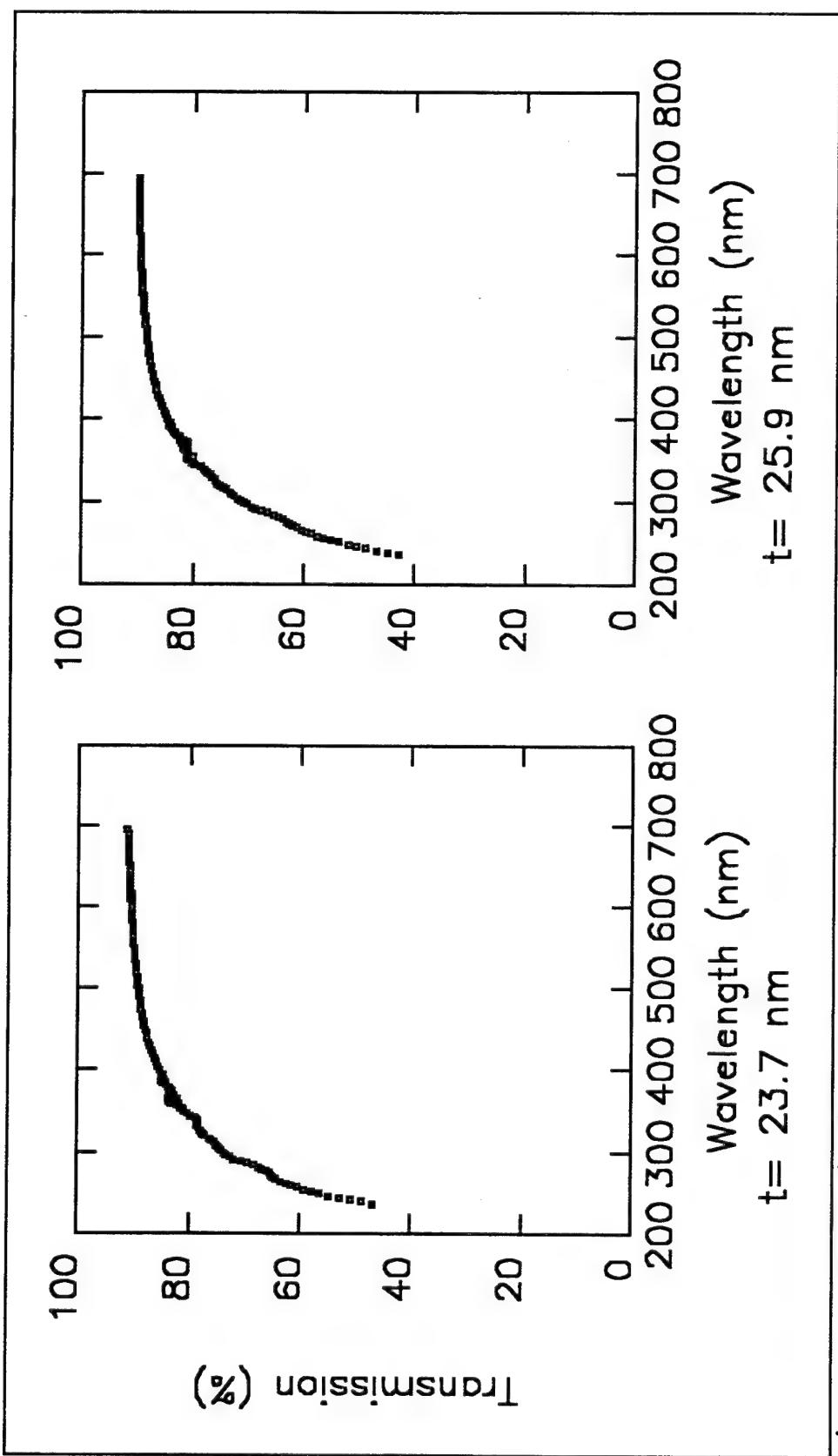


Figure C5 Transmission spectra measured during photodeposition of DEHP.

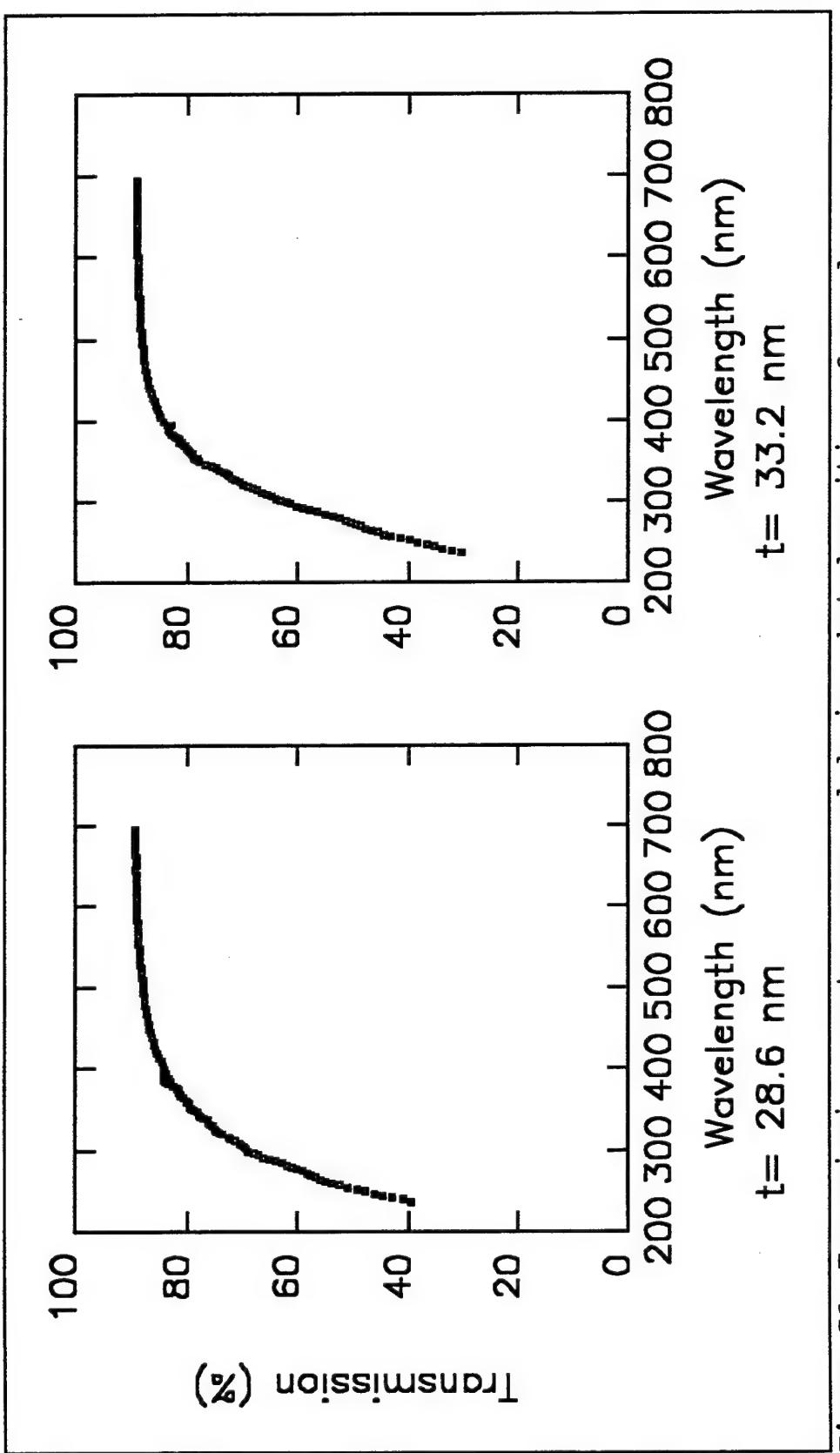


Figure C6 Transmission spectra measured during photodeposition of squalene.

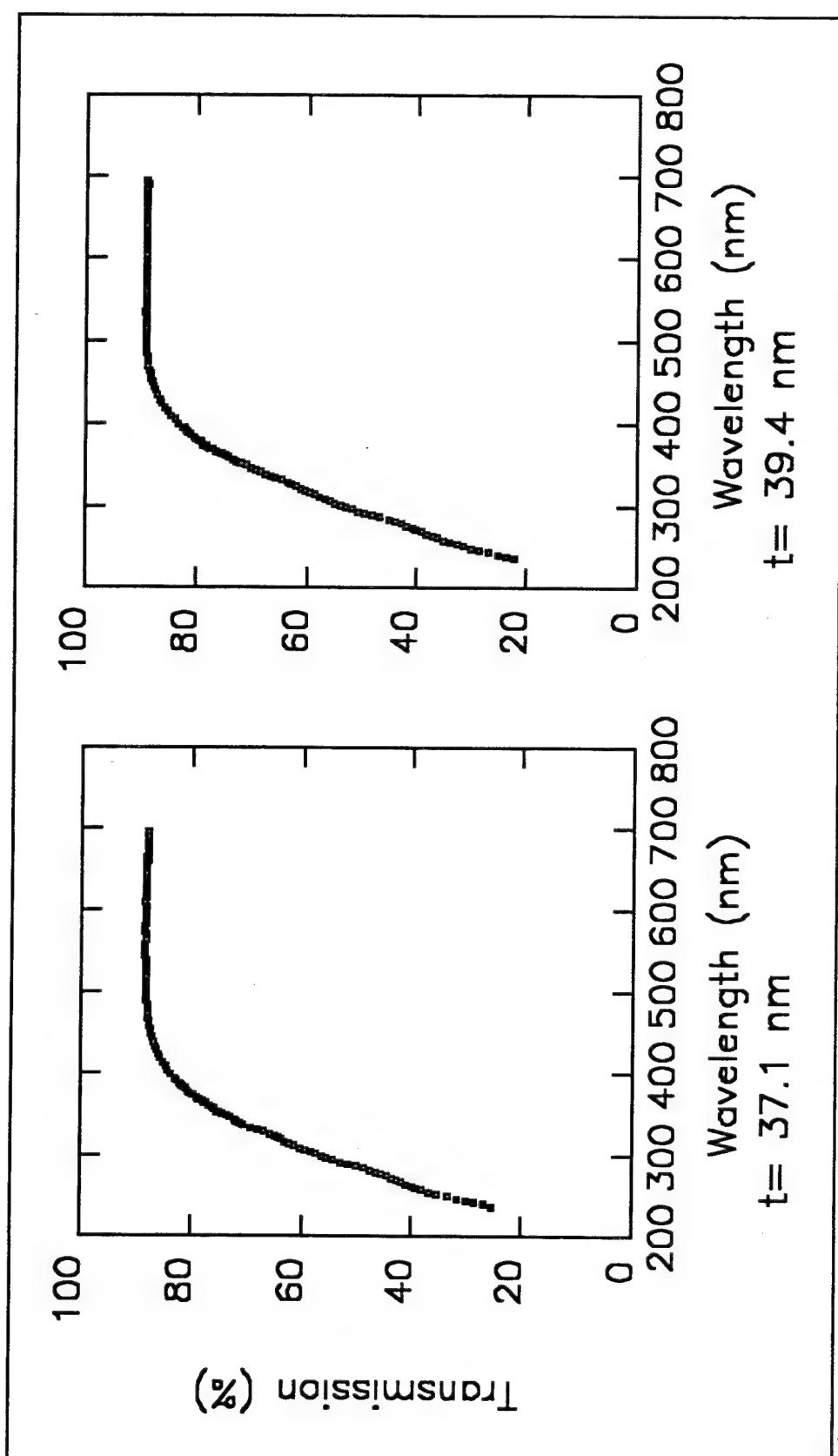


Figure C7 Transmission spectra measured during photodeposition of DEHP.

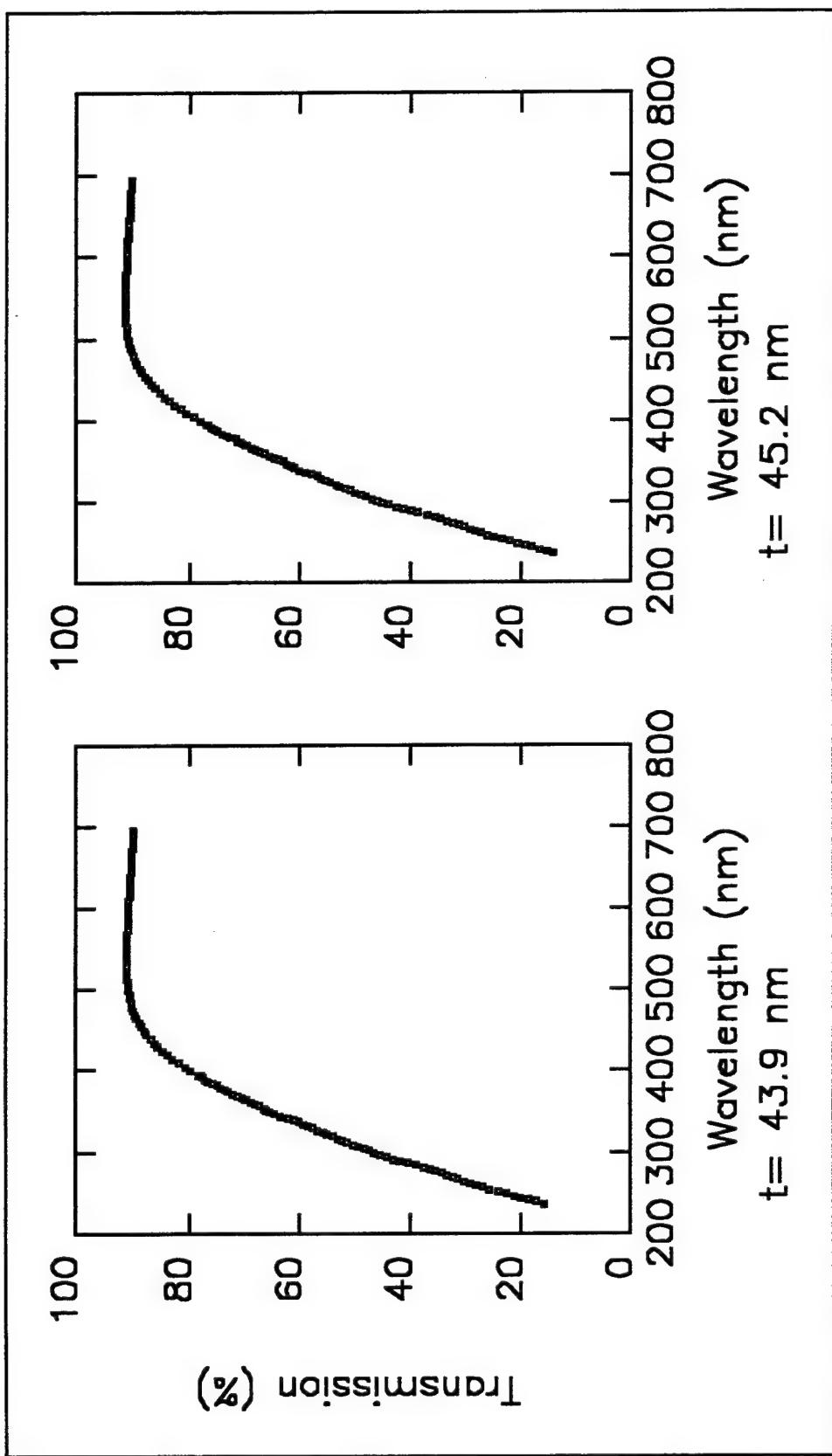


Figure C8 Transmission spectra measured during photodeposition of DEHP.

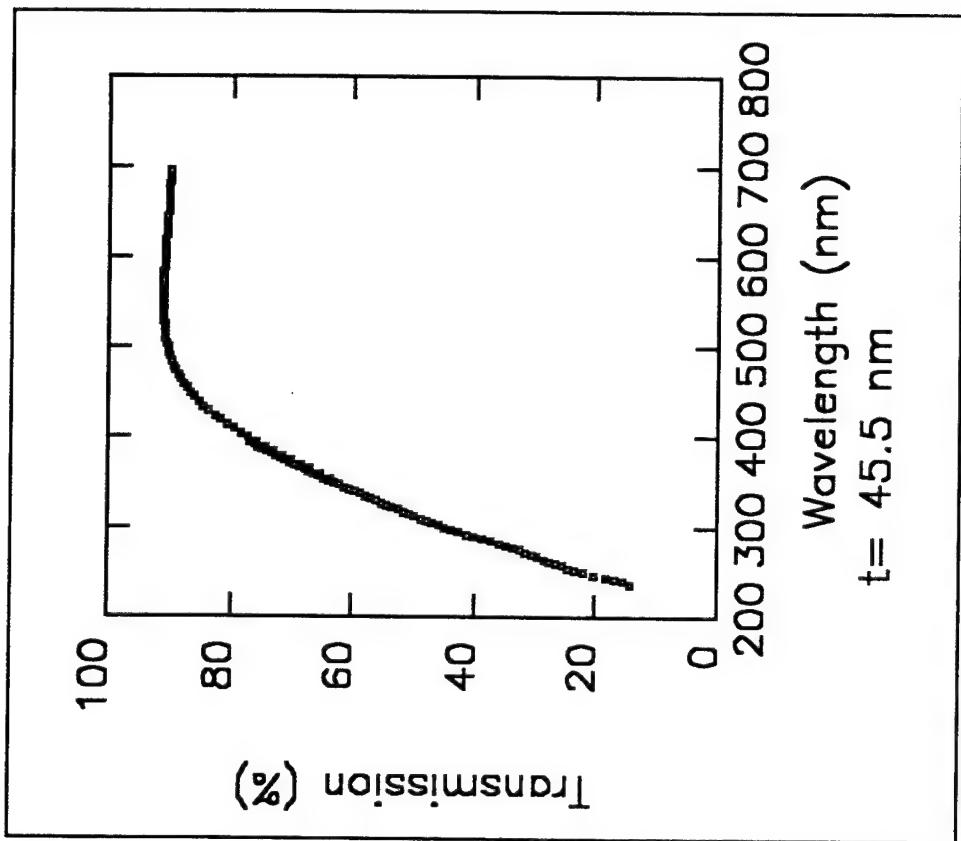


Figure C9 Transmission spectra measured during photodeposition of DEHP.

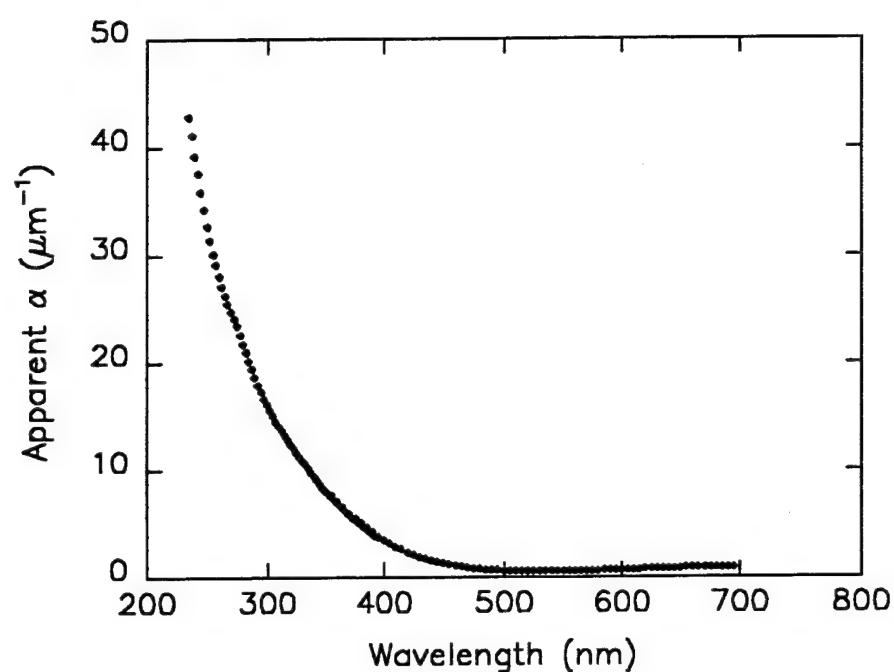


Figure C10. Apparent absorption coefficient obtained from the fits to the Beer-Lambert absorption law. Linear plot

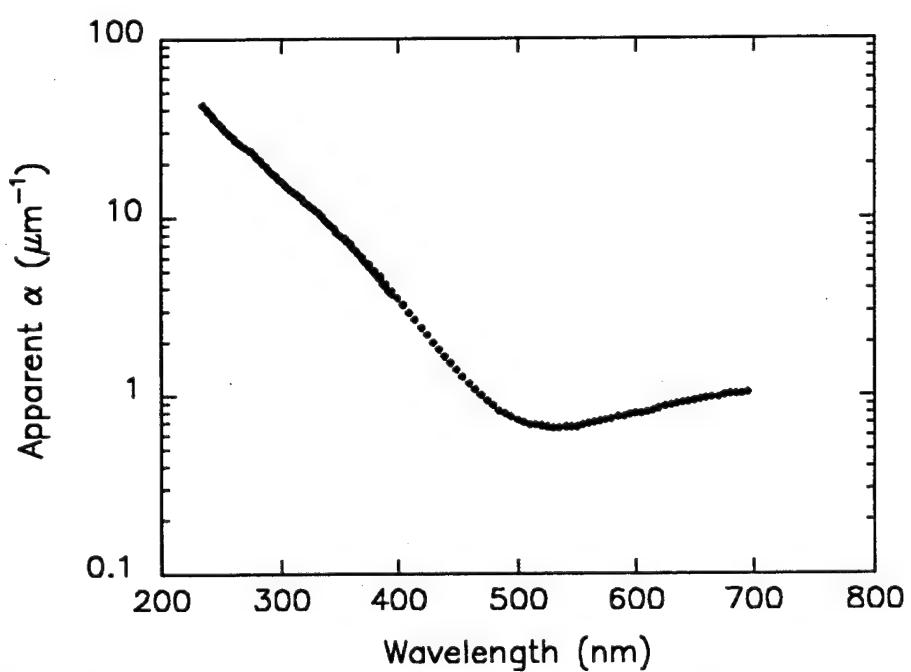


Figure C11. Apparent absorption coefficient obtained from the data fits to the Beer-Lambert absorption law. Log plot

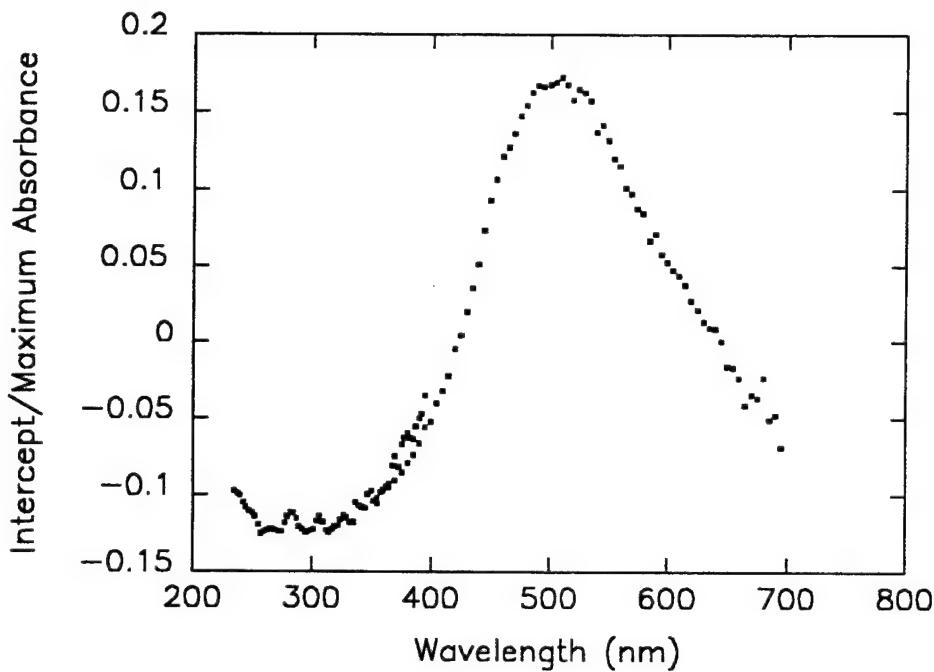


Figure C12. Plot of the ratio of the intercept of the Beer's law fit to the DEHP absorption data to the maximum value of absorbance.

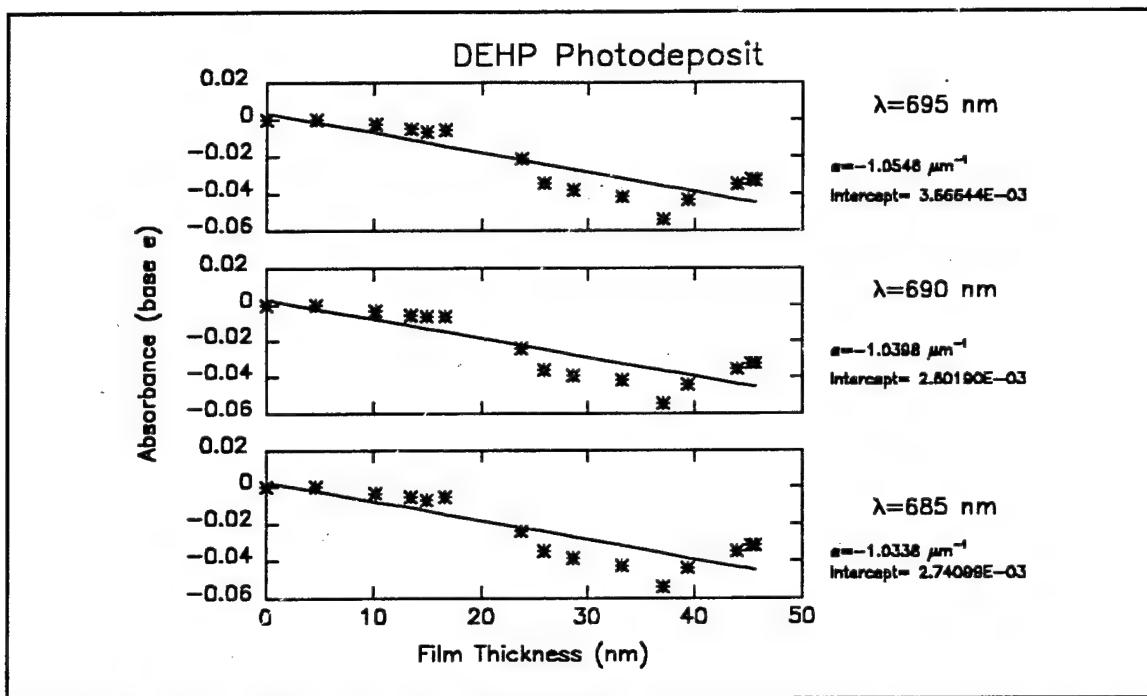


Figure C13a Fits of the measured transmission spectra to the Beer-Lambert absorption law for the dioctyl phthalate (DEHP) photodeposit. (Visible wavelength range)

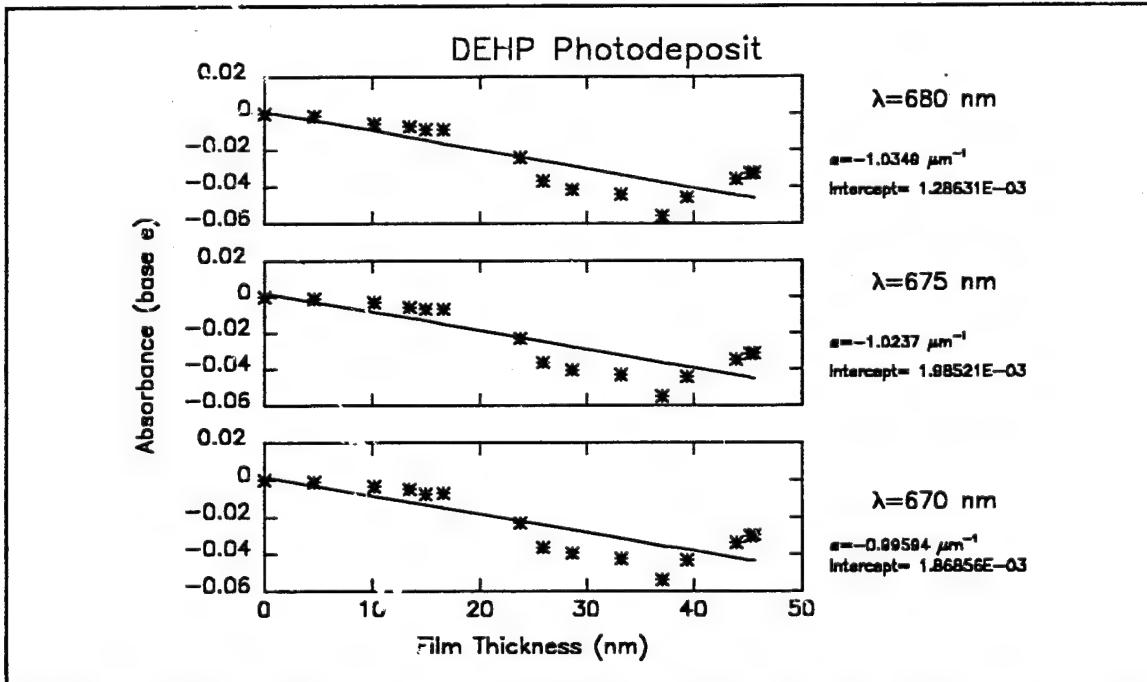


Figure C13b Fits of the measured transmission spectra to the Beer-Lambert absorption law for the dioctyl phthalate (DEHP) photodeposit. (Visible wavelength range)

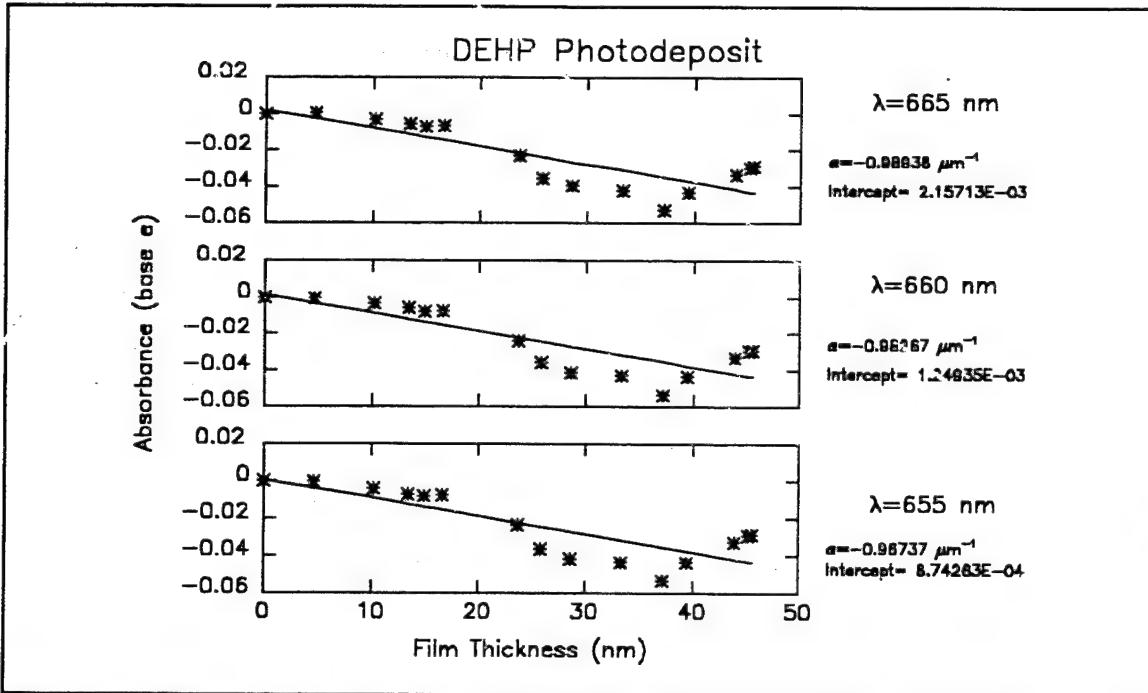


Figure C13c Fits of the measured transmission spectra to the Beer-Lambert absorption law for the dioctyl phthalate (DEHP) photodeposit. (Visible wavelength range)

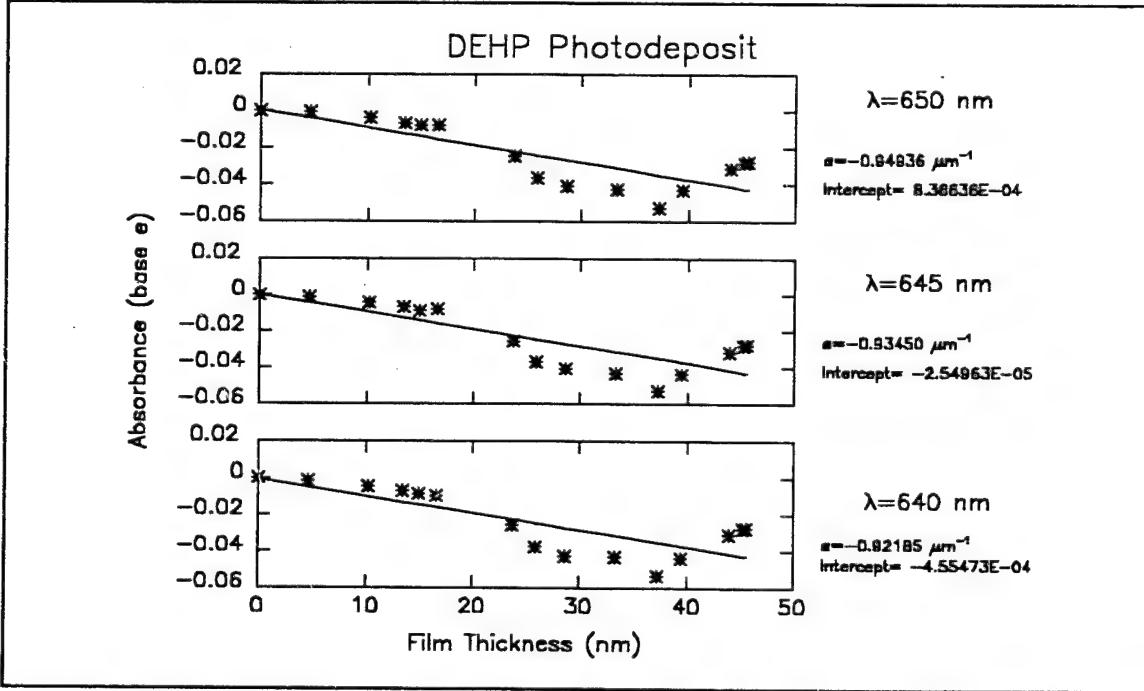


Figure C13d Fits of the measured transmission spectra to the Beer-Lambert absorption law for the dioctyl phthalate (DEHP) photodeposit. (Visible wavelength range)

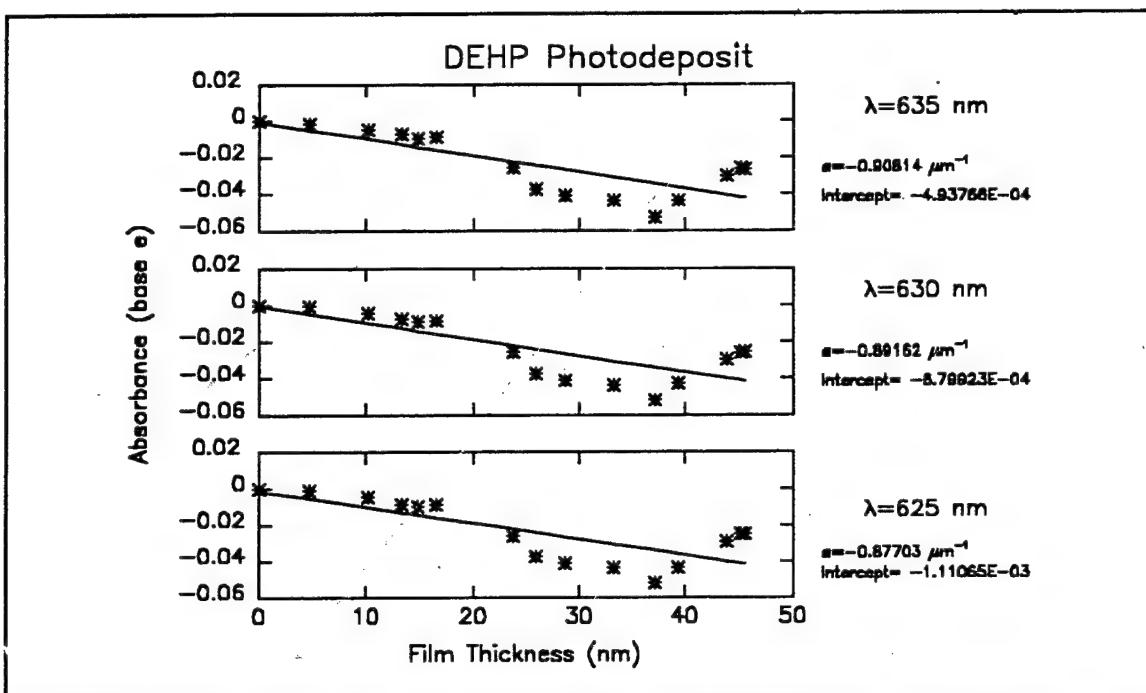


Figure C13e Fits of the measured transmission spectra to the Beer-Lambert absorption law for the dioctyl phthalate (DEHP) photodeposit. (Visible wavelength range)

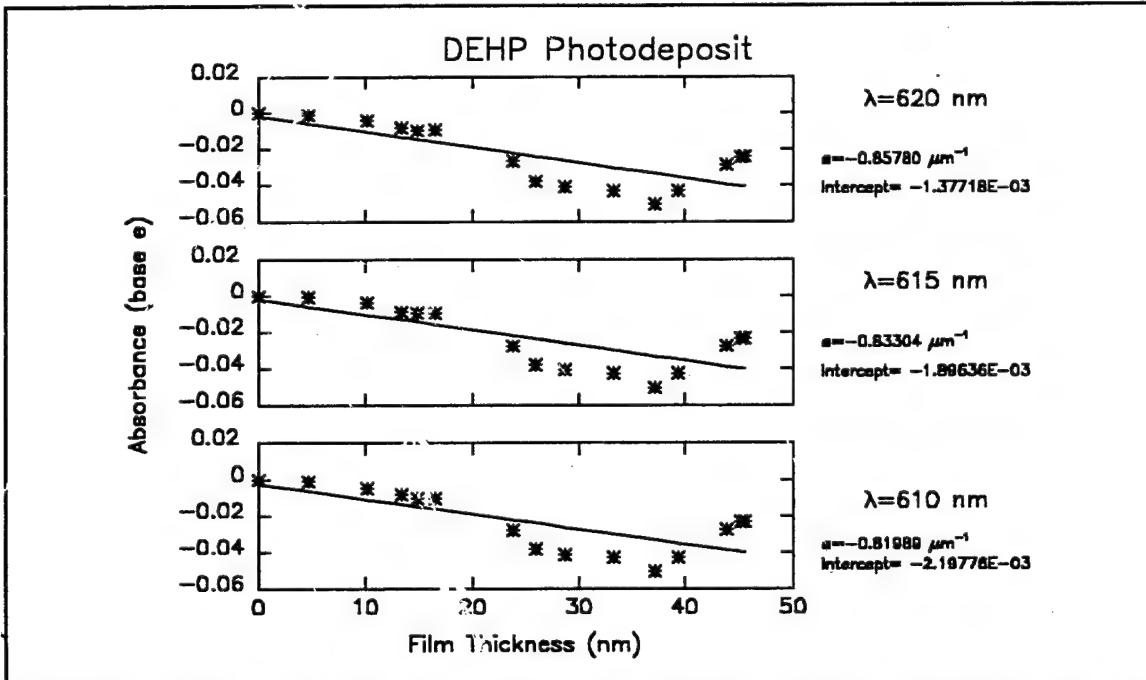


Figure C13f Fits of the measured transmission spectra to the Beer-Lambert absorption law for the dioctyl phthalate (DEHP) photodeposit. (Visible wavelength range)

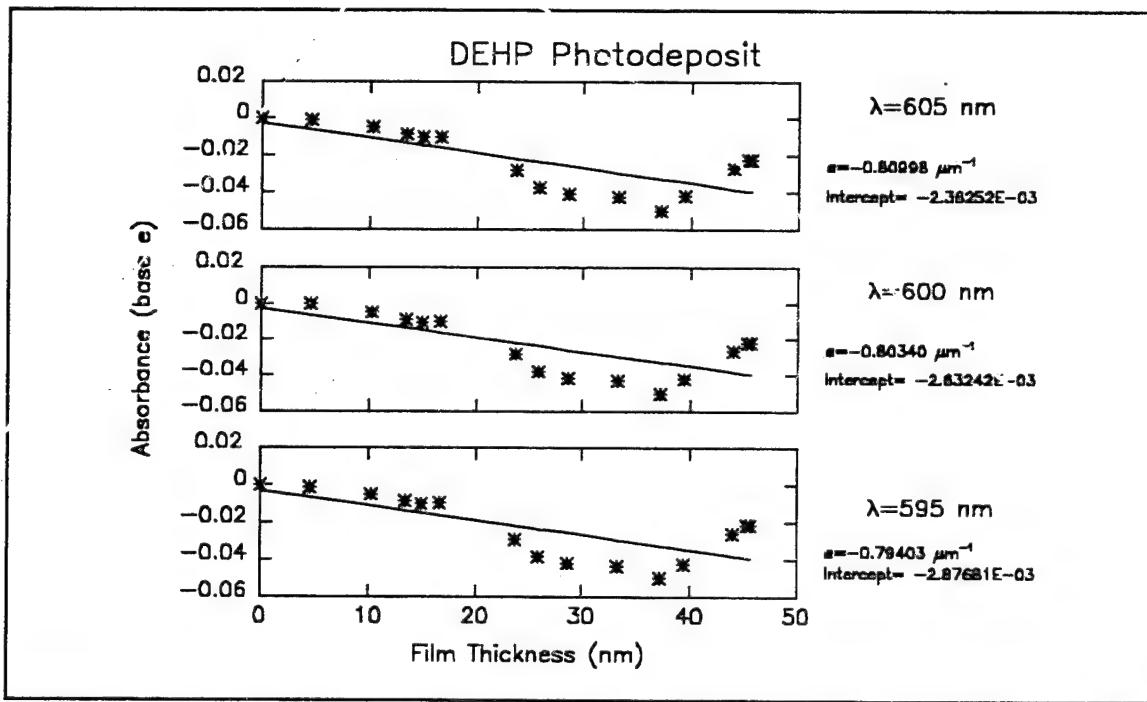


Figure C13g Fits of the measured transmission spectra to the Beer-Lambert absorption law for the dioctyl phthalate (DEHP) photodeposit. (Visible wavelength range)

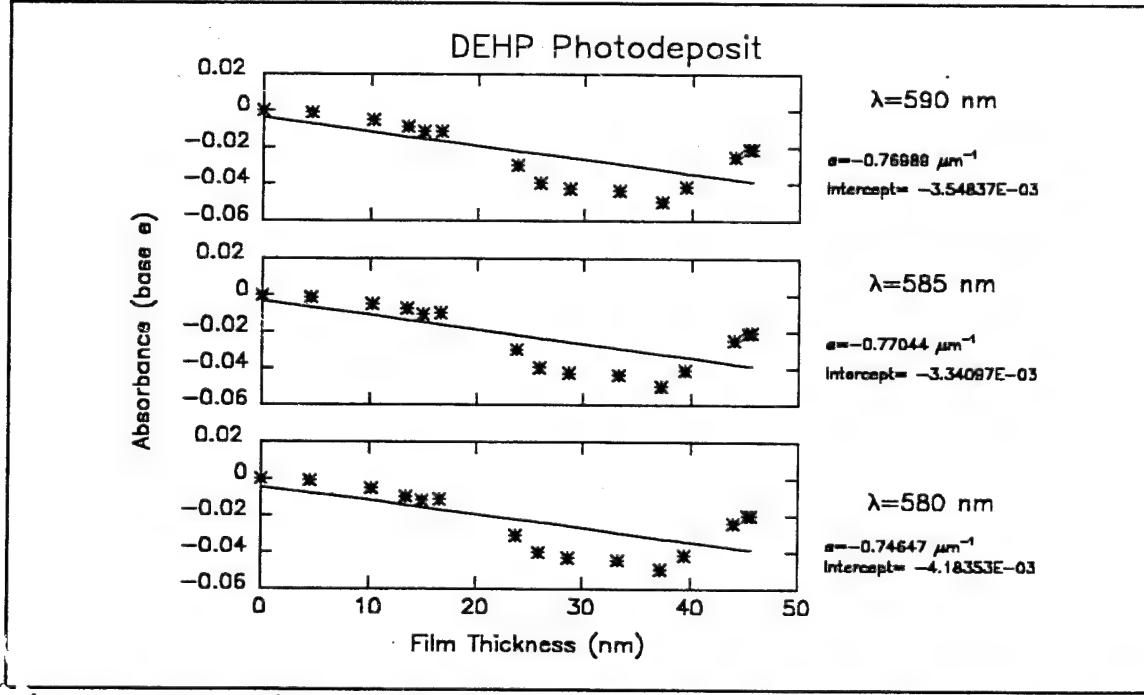


Figure C13h Fits of the measured transmission spectra to the Beer-Lambert absorption law for the dioctyl phthalate (DEHP) photodeposit. (Visible wavelength range)

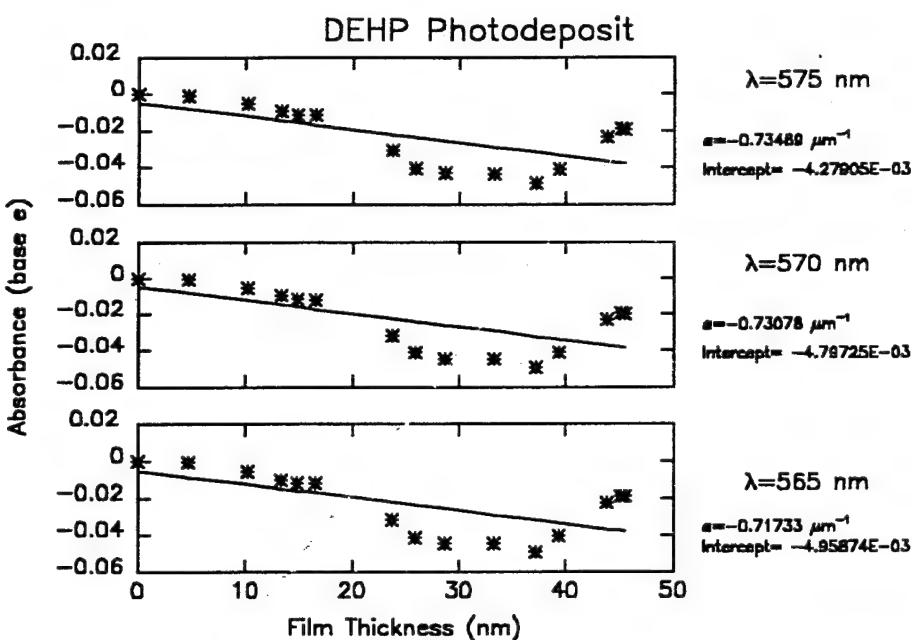


Figure C13i Fits of the measured transmission spectra to the Beer-Lambert absorption law for the dioctyl phthalate (DEHP) photodeposit. (Visible wavelength range)

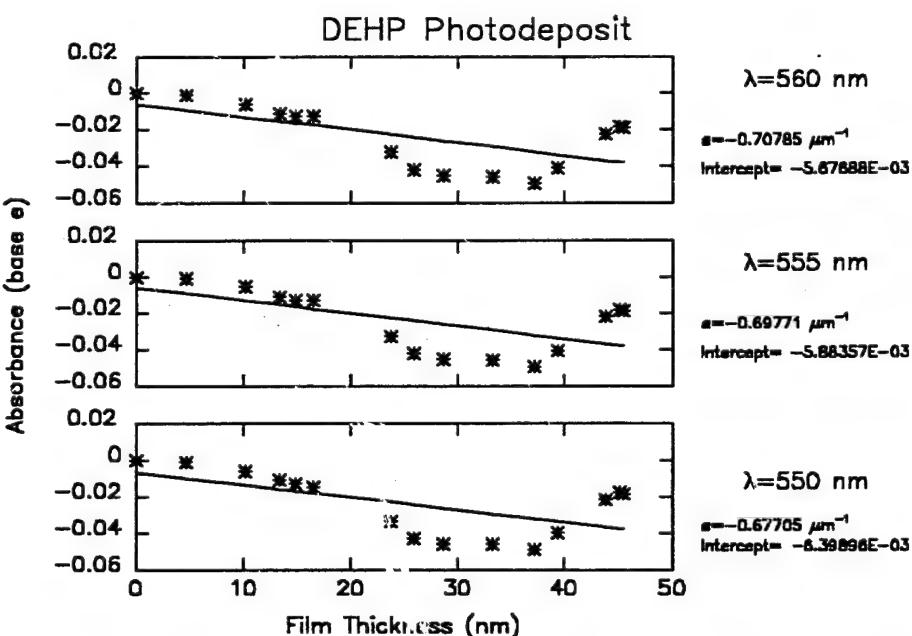


Figure C13j Fits of the measured transmission spectra to the Beer-Lambert absorption law for the dioctyl phthalate (DEHP) photodeposit. (Visible wavelength range)

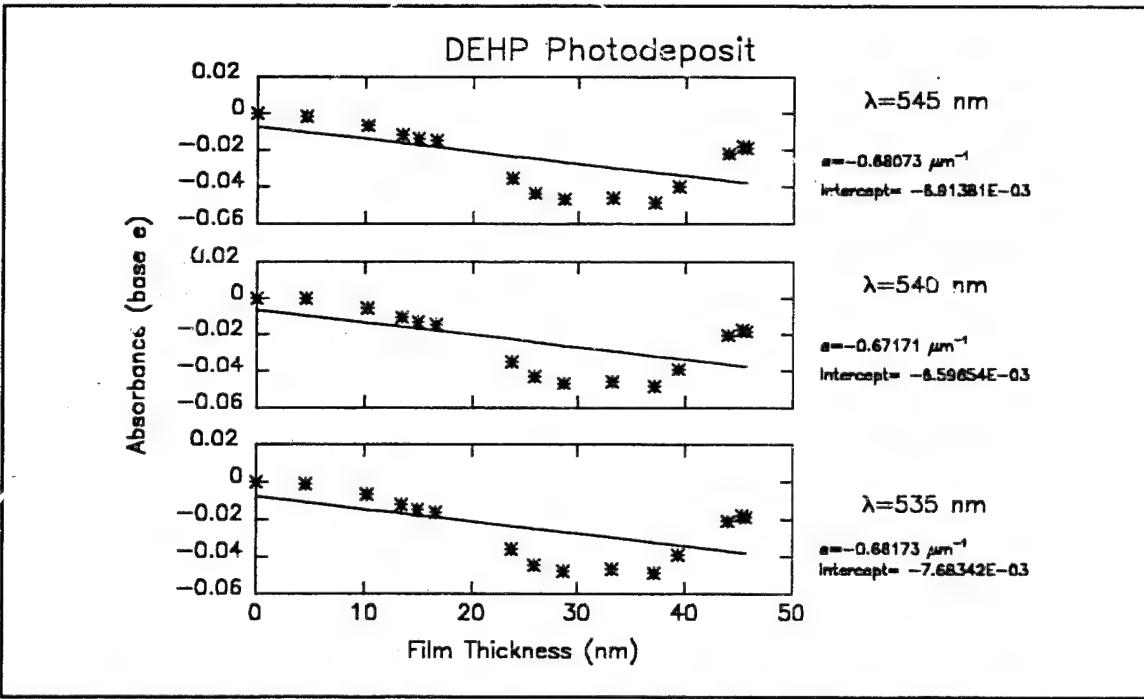


Figure C13k Fits of the measured transmission spectra to the Beer-Lambert absorption law for the dioctyl phthalate (DEHP) photodeposit. (Visible wavelength range)

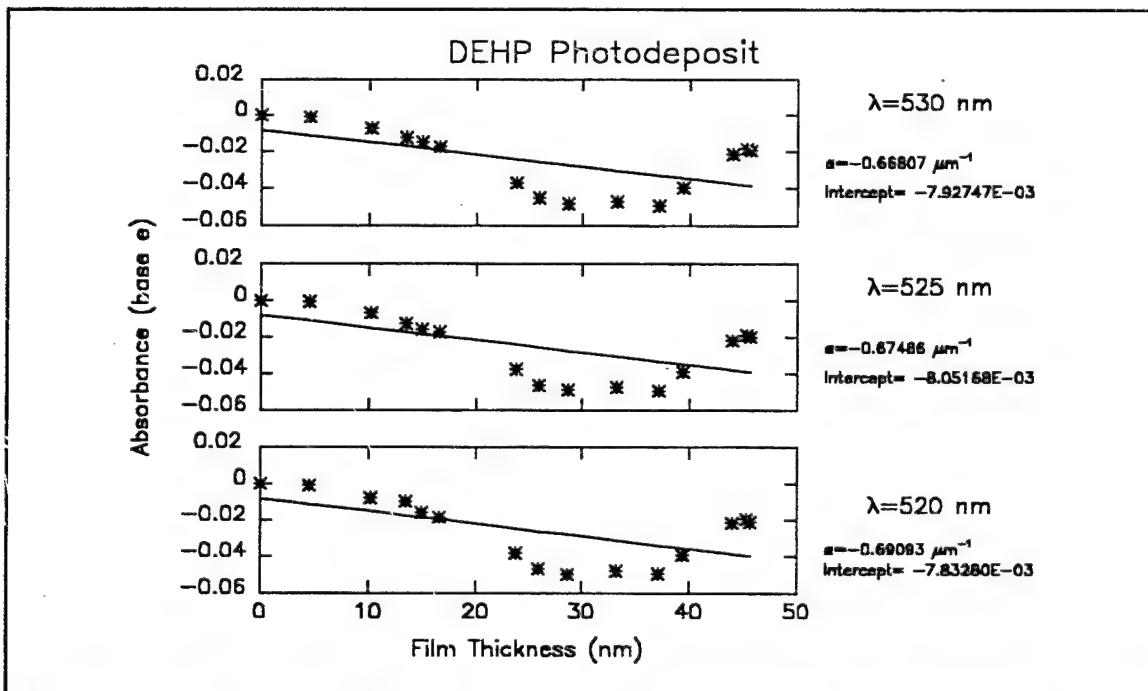


Figure C13l Fits of the measured transmission spectra to the Beer-Lambert absorption law for the dioctyl phthalate (DEHP) photodeposit. (Visible wavelength range)

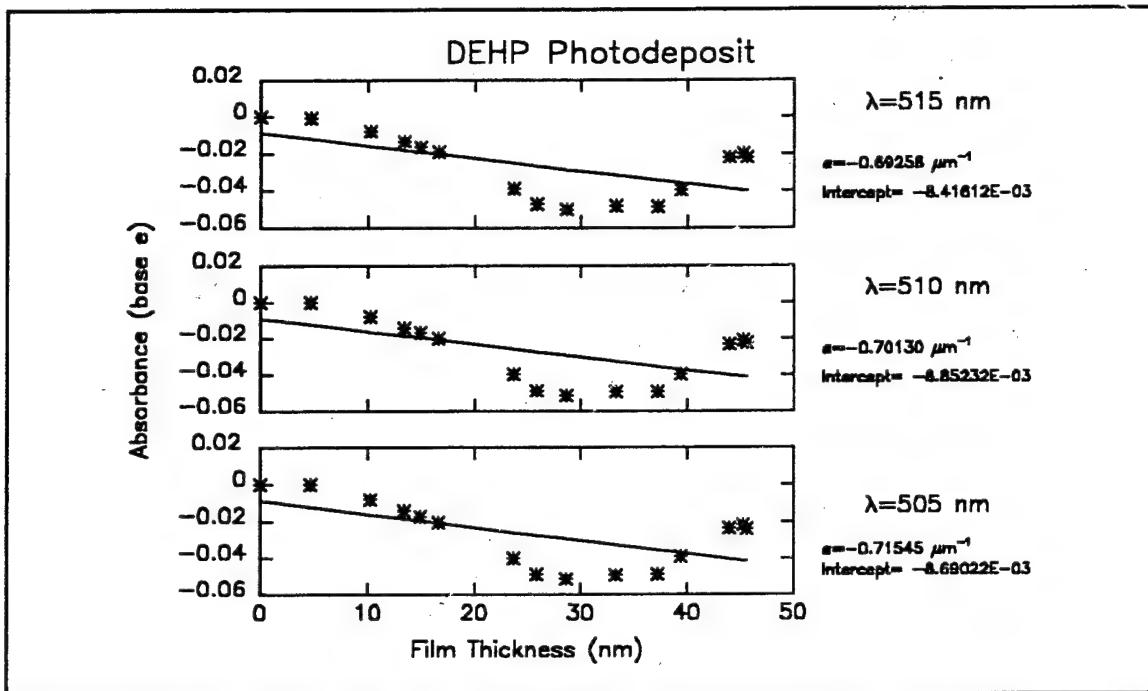


Figure C13m Fits of the measured transmission spectra to the Beer-Lambert absorption law for the dioctyl phthalate (DEHP) photodeposit. (Visible wavelength range)

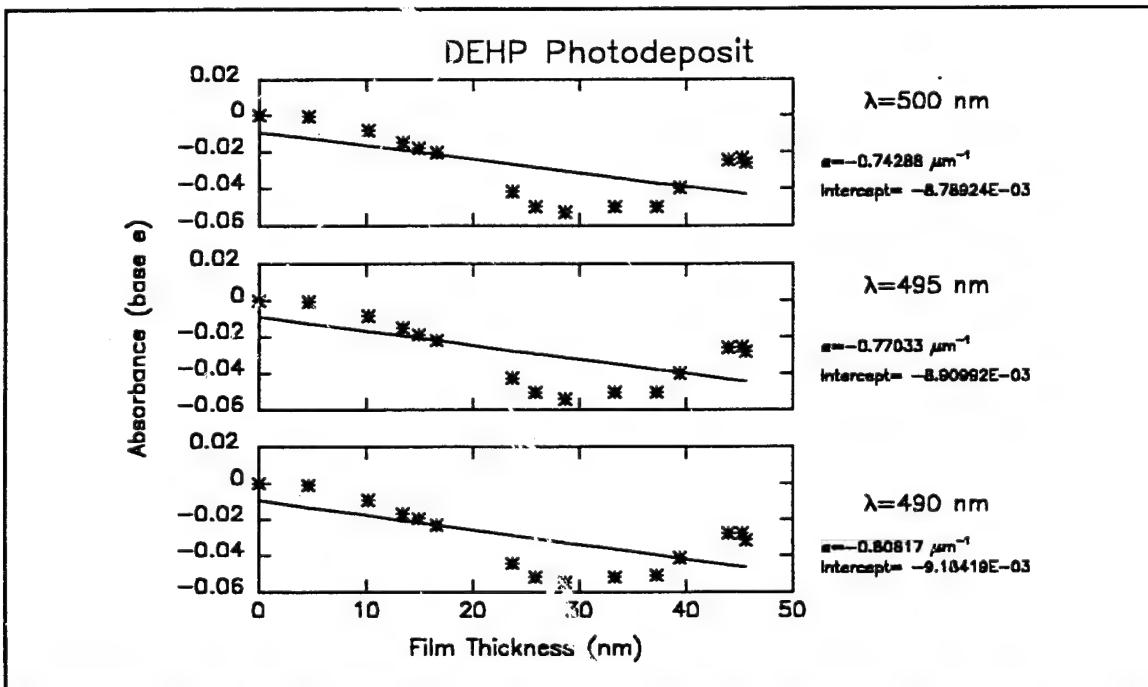


Figure C13n Fits of the measured transmission spectra to the Beer-Lambert absorption law for the dioctyl phthalate (DEHP) photodeposit. (Visible wavelength range)

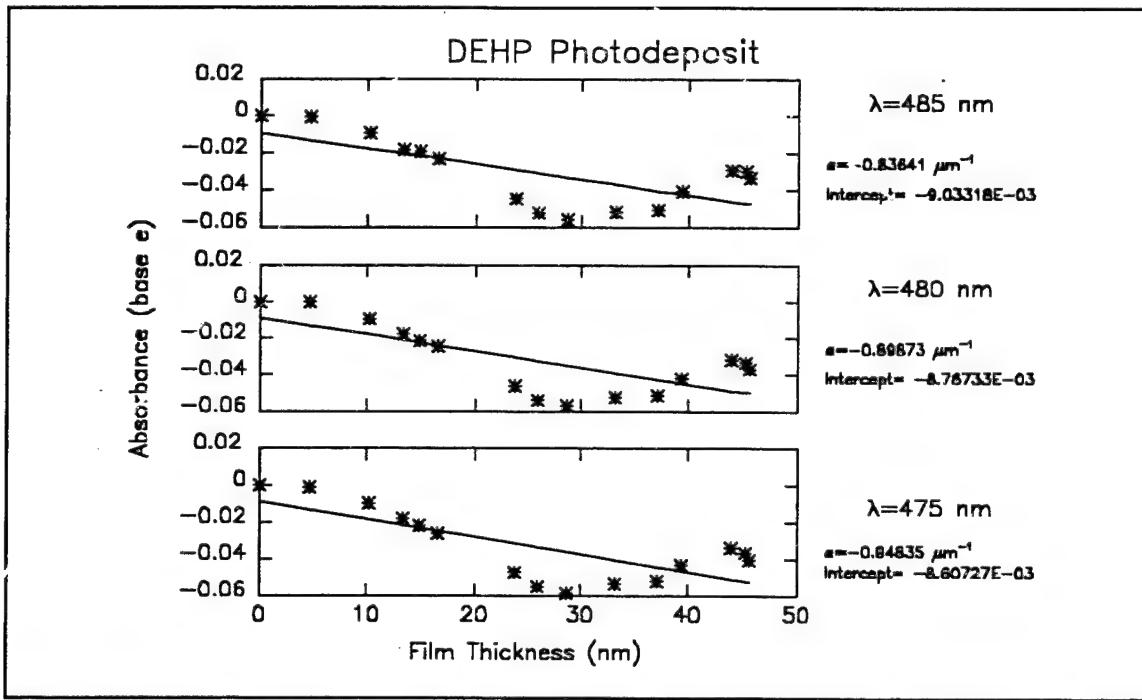


Figure C13o Fits of the measured transmission spectra to the Beer-Lambert absorption law for the dioctyl phthalate (DEHP) photodeposit. (Visible wavelength range)

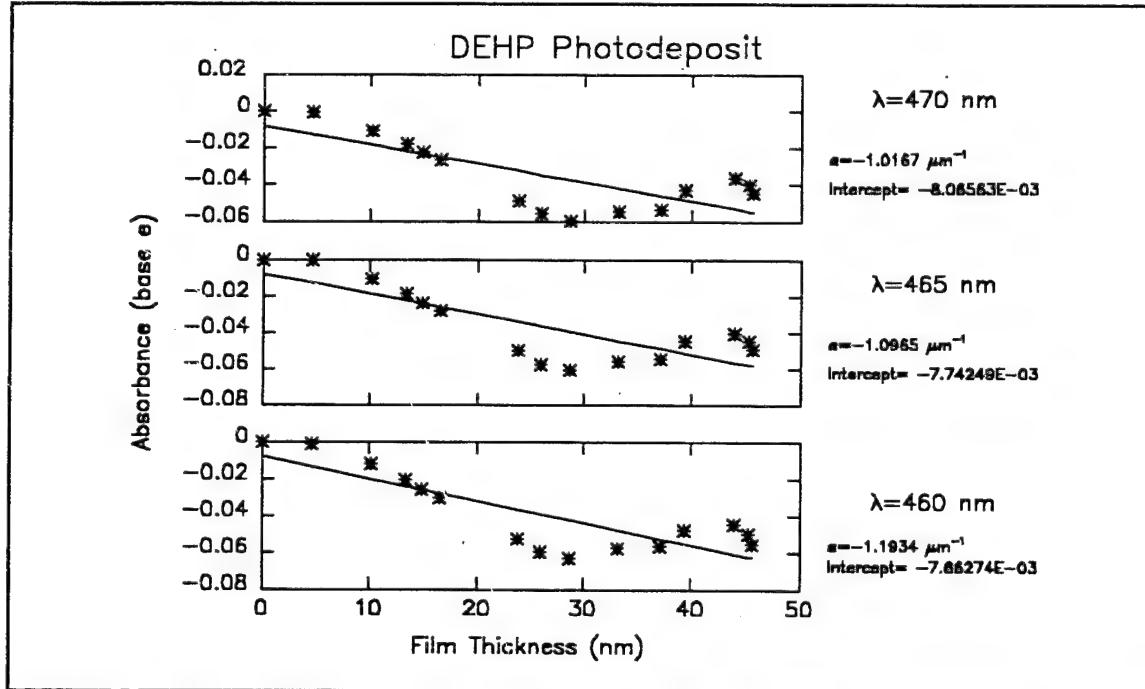


Figure C13p Fits of the measured transmission spectra to the Beer-Lambert absorption law for the dioctyl phthalate (DEHP) photodeposit. (Visible wavelength range)

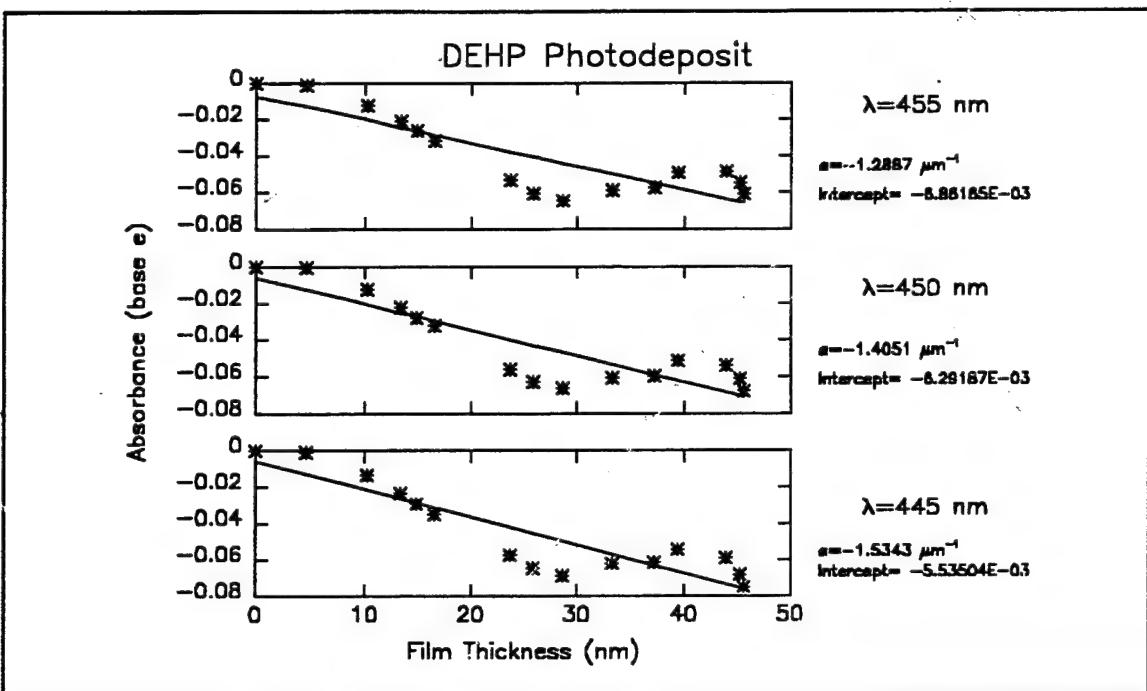


Figure C13q Fits of the measured transmission spectra to the Beer-Lambert absorption law for the dioctyl phthalate (DEHP) photodeposit. (Visible wavelength range)

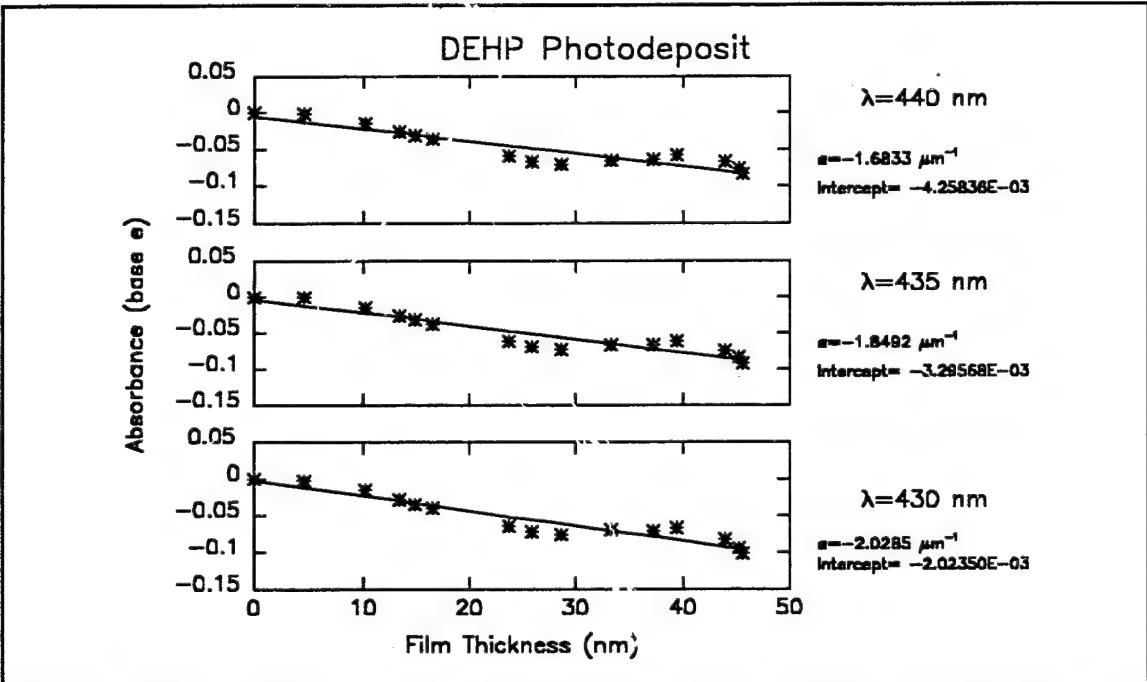


Figure C13r Fits of the measured transmission spectra to the Beer-Lambert absorption law for the dioctyl phthalate (DEHP) photodeposit. (Visible wavelength range)

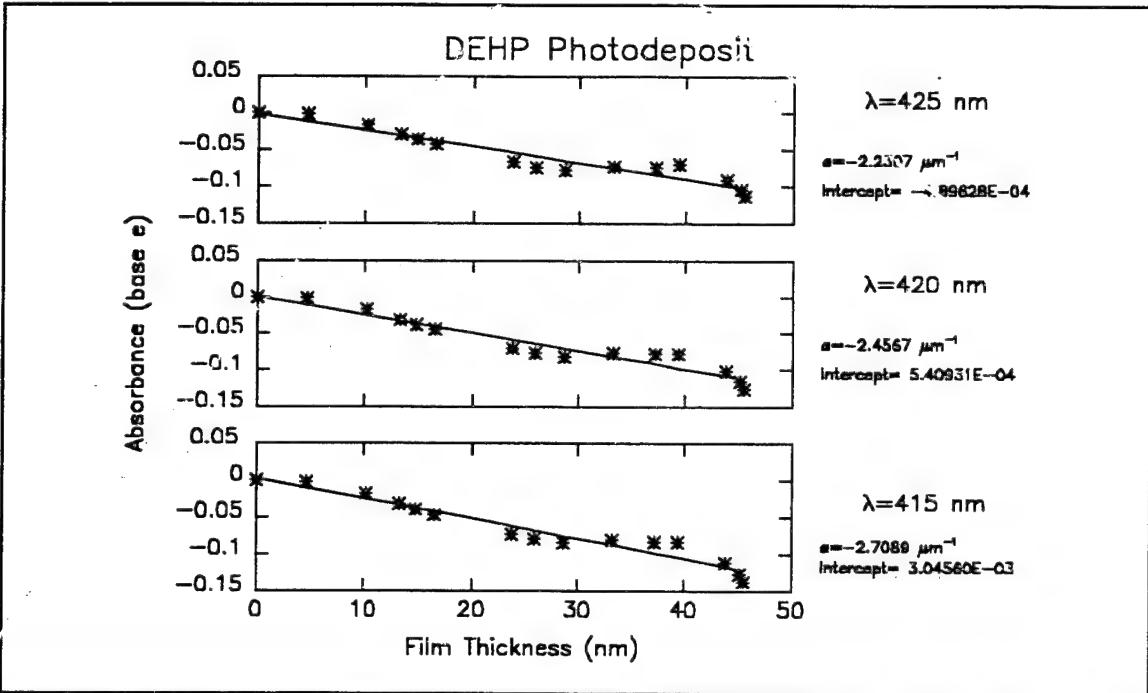


Figure C13s Fits of the measured transmission spectra to the Beer-Lambert absorption law for the dioctyl phthalate (DEHP) photodeposit. (Visible wavelength range)

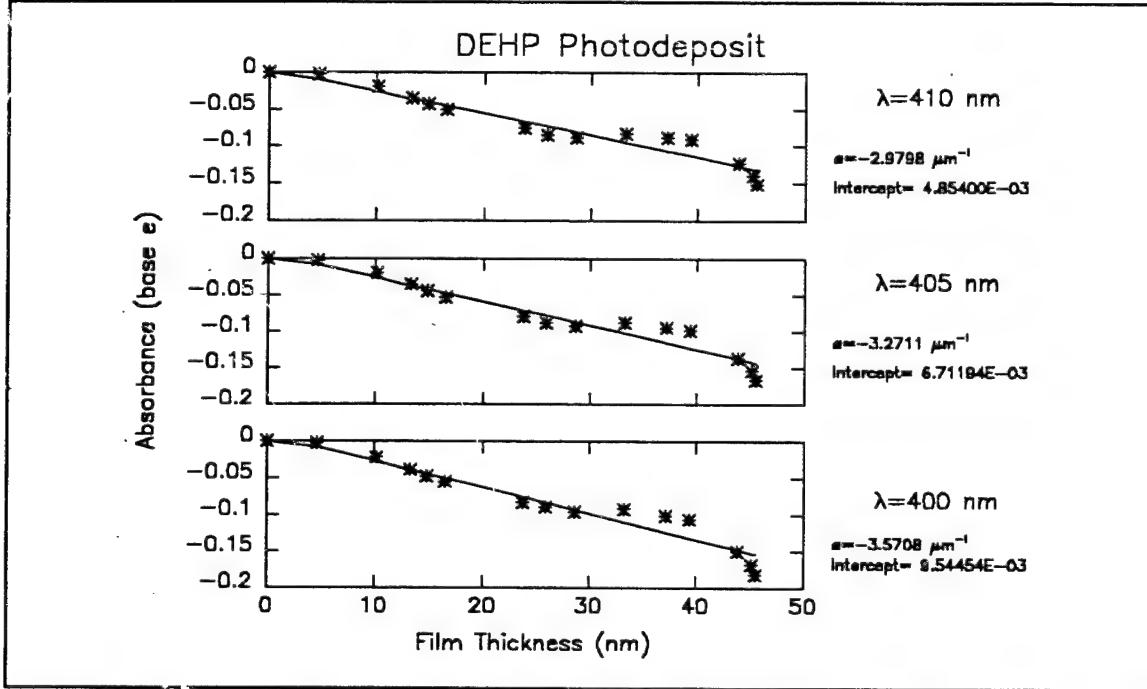


Figure C13t Fits of the measured transmission spectra to the Beer-Lambert absorption law for the dioctyl phthalate (DEHP) photodeposit. (Visible wavelength range)

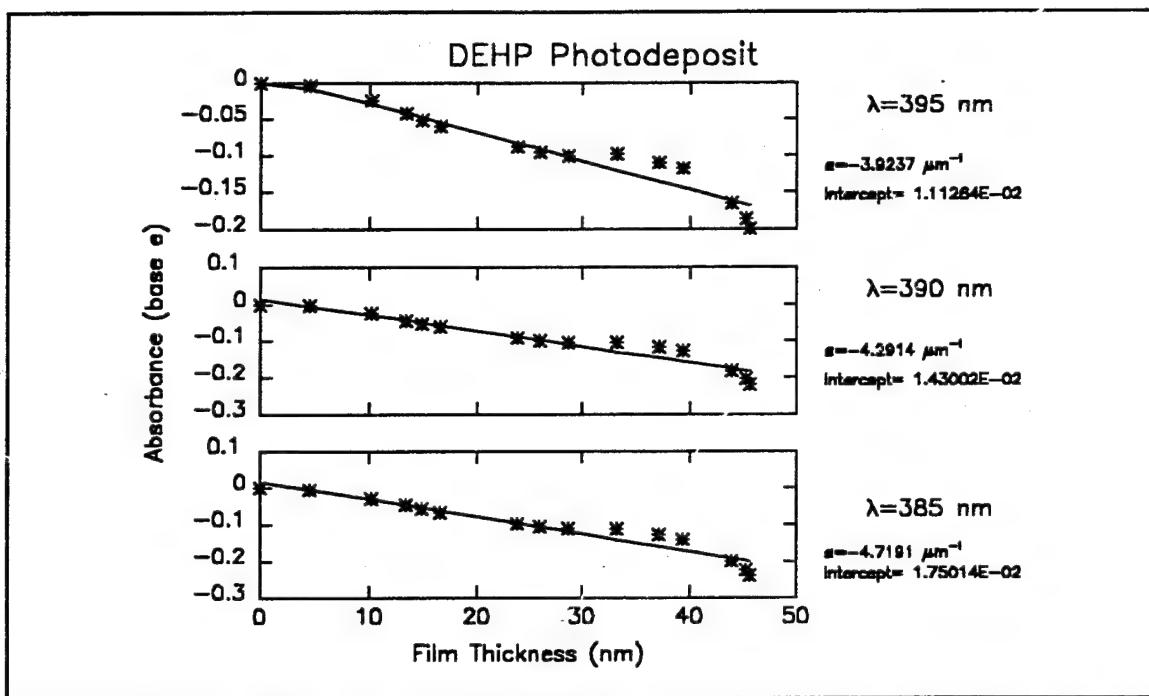


Figure C13u Fits of the measured transmission spectra to the Beer-Lambert absorption law for the dioctyl phthalate (DEHP) photodeposit. (Visible wavelength range)

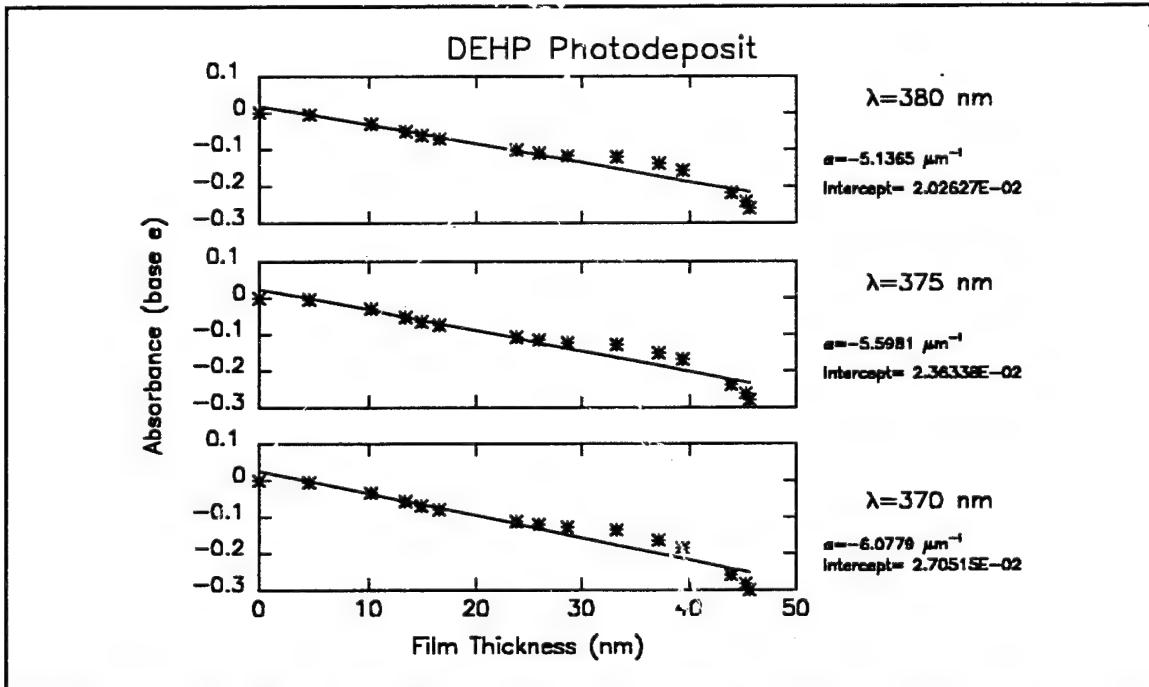


Figure C13v Fits of the measured transmission spectra to the Beer-Lambert absorption law for the dioctyl phthalate (DEHP) photodeposit. (Visible wavelength range)

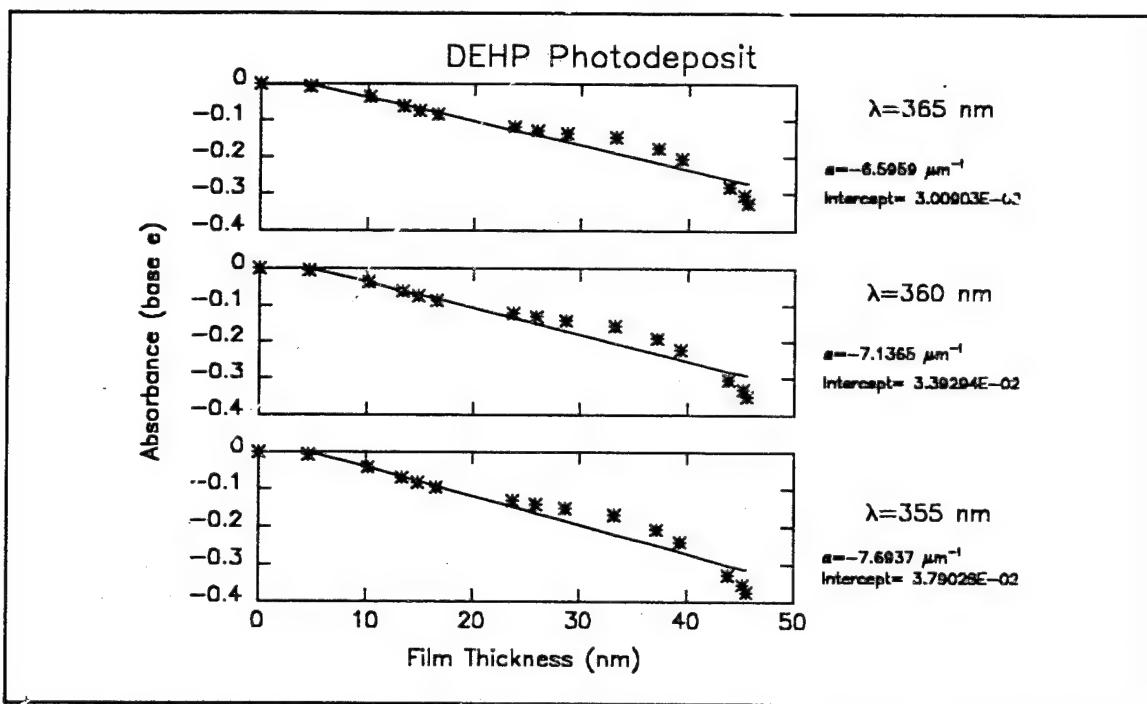


Figure C13w Fits of the measured transmission spectra to the Beer-Lambert absorption law for the dioctyl phthalate (DEHP) photodeposit. (Visible wavelength range)

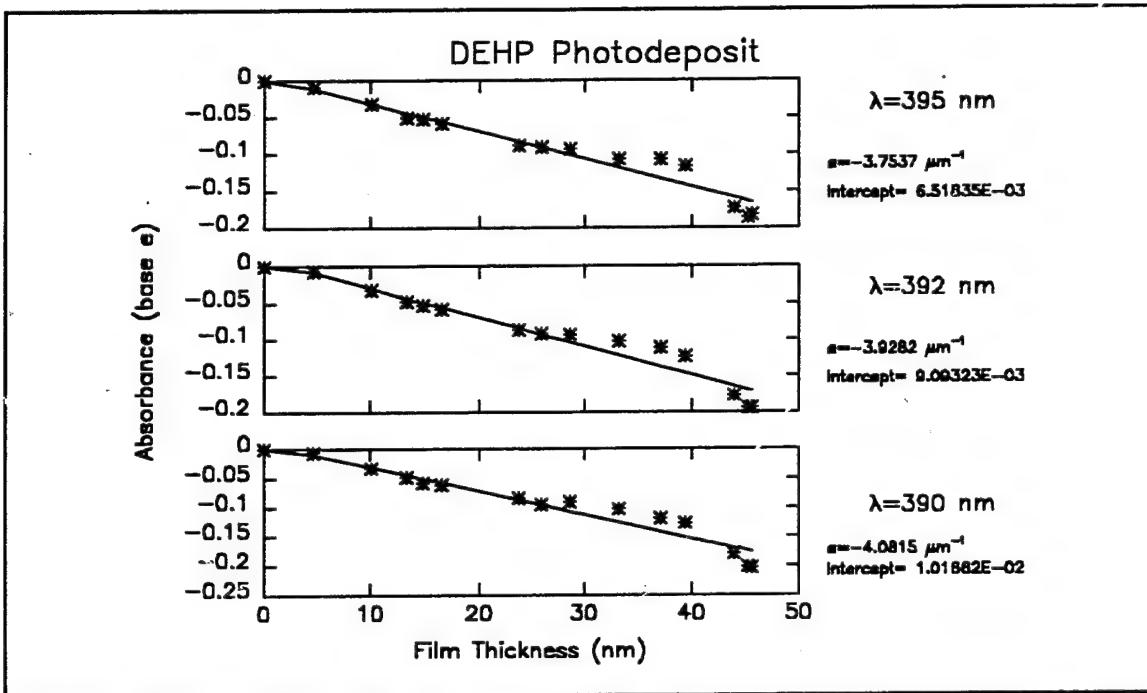


Figure C14a Fits of the measured transmission spectra to the Beer-Lambert absorption law for the dioctyl phthalate (DEHP) photodeposit. (Ultraviolet wavelength range)

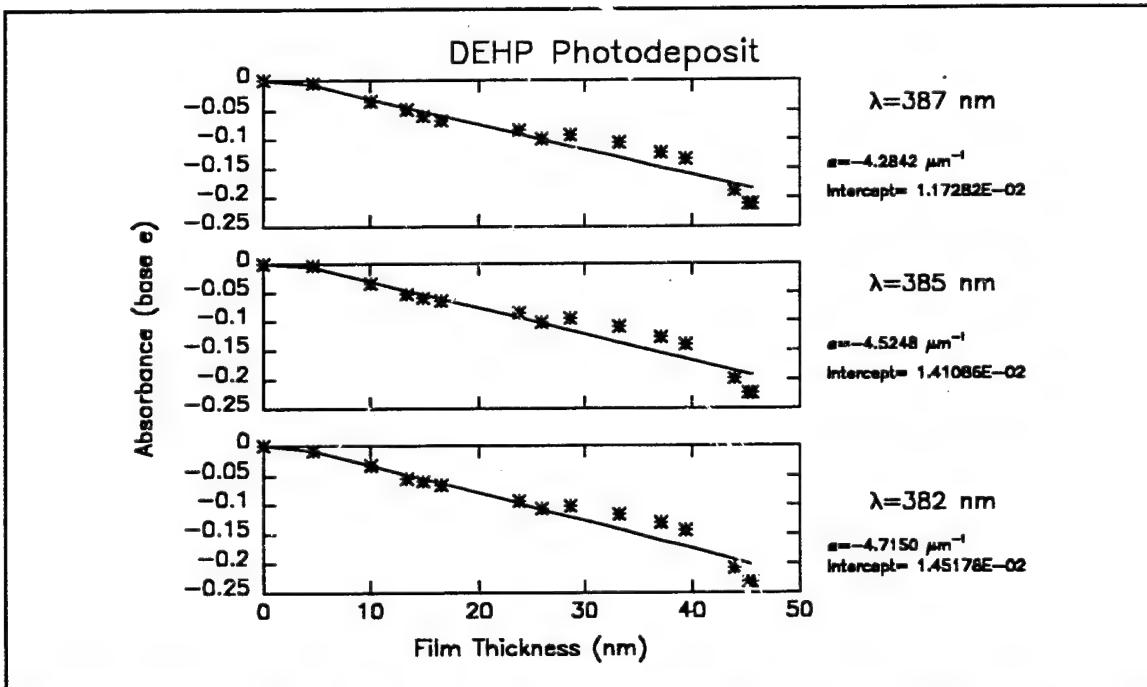


Figure C14b Fits of the measured transmission spectra to the Beer-Lambert absorption law for the dioctyl phthalate (DEHP) photodeposit. (Ultraviolet wavelength range)

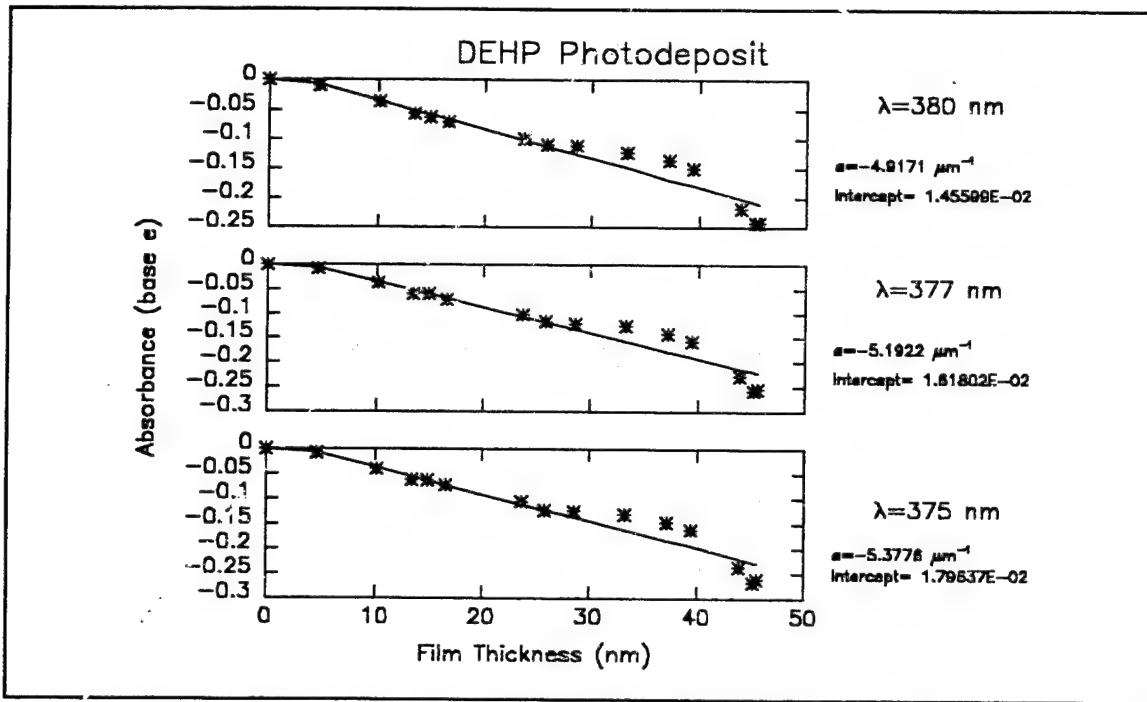


Figure C14c Fits of the measured transmission spectra to the Beer-Lambert absorption law for the dioctyl phthalate (DEHP) photodeposit. (Ultraviolet wavelength range)

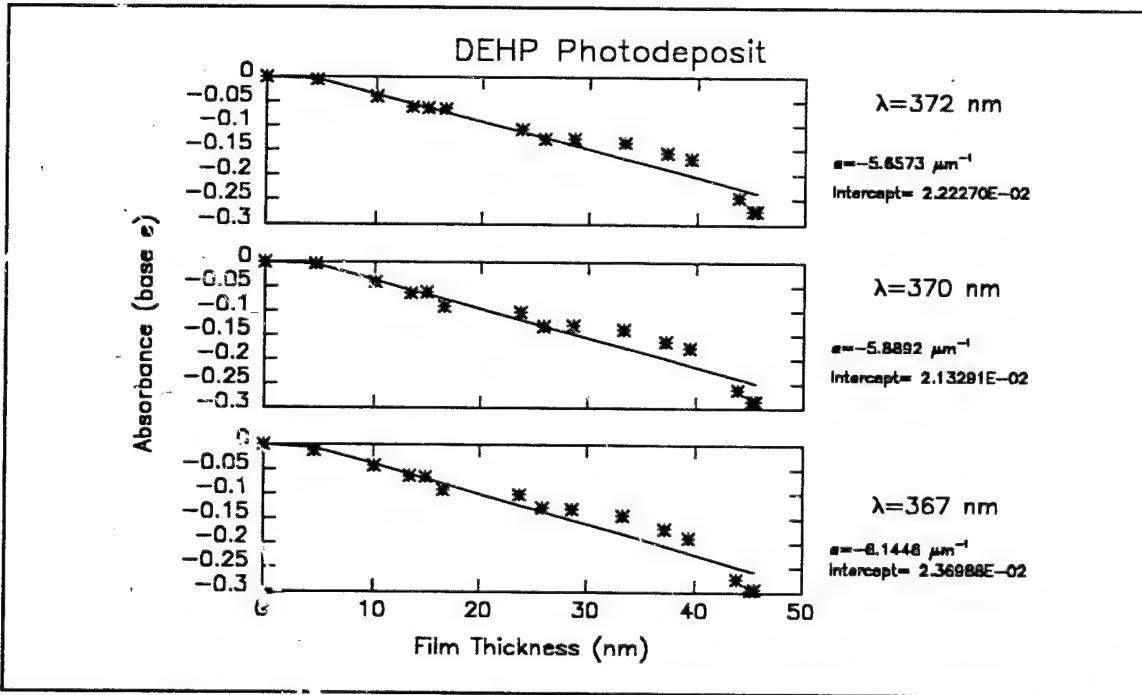


Figure C14d Fit of the measured transmission spectra to the Beer-Lambert absorption law for the dioctyl phthalate (DEHP) photodeposit. (Ultraviolet wavelength range)

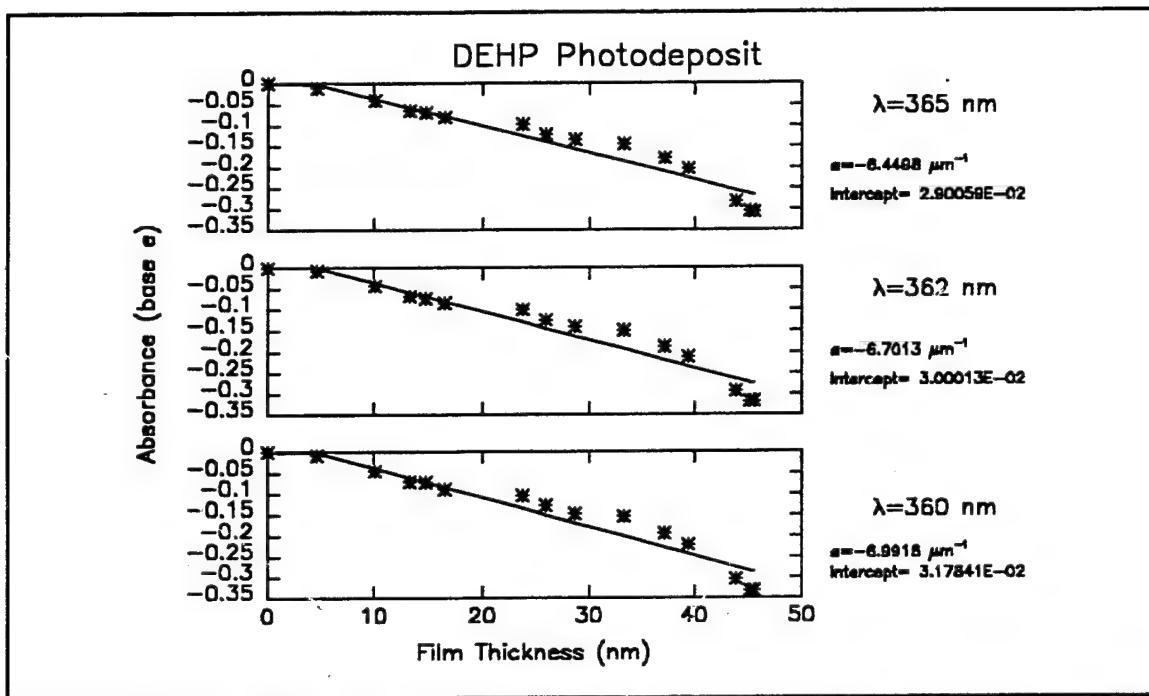


Figure C14e Fits of the measured transmission spectra to the Beer-Lambert absorption law for the dioctyl phthalate (DEHP) photodeposit. (Ultraviolet wavelength range)

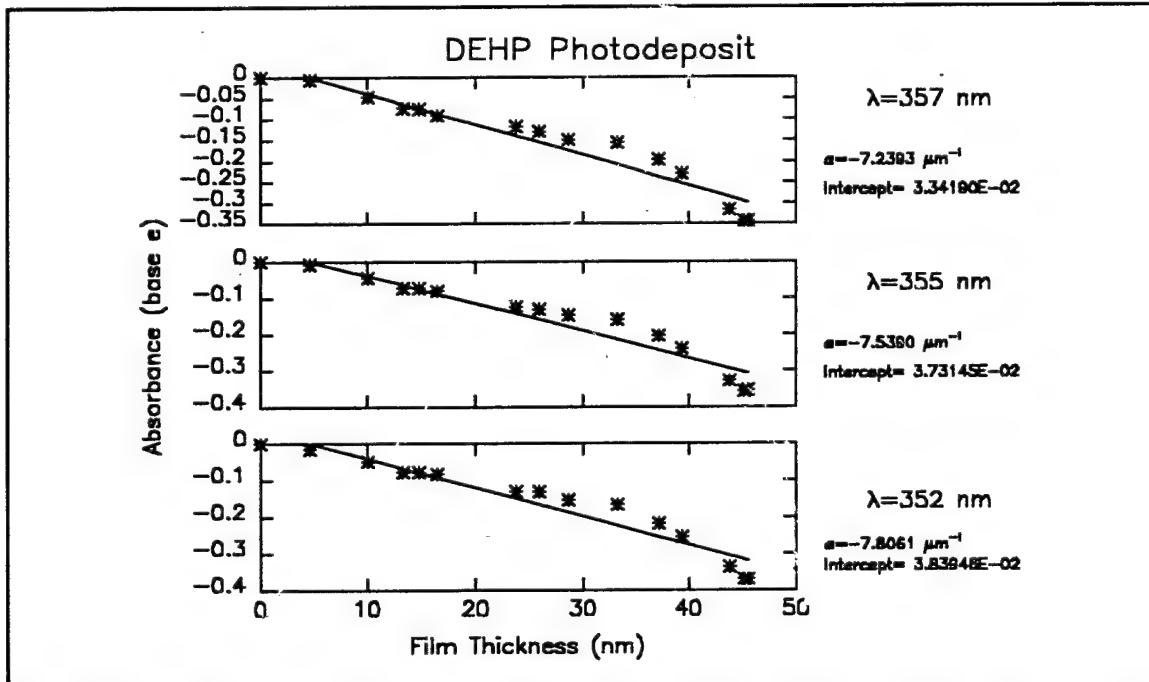


Figure C14f Fits of the measured transmission spectra to the Beer-Lambert absorption law for the dioctyl phthalate (DEHP) photodeposit. (Ultraviolet wavelength range)

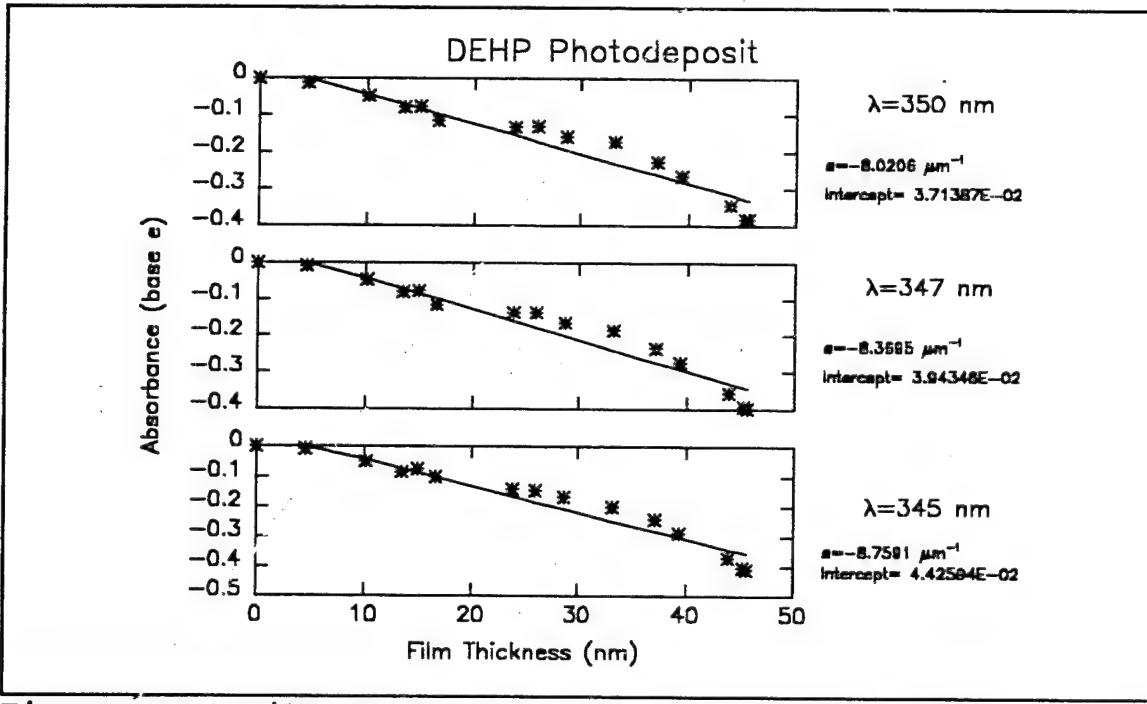


Figure C14g Fits of the measured transmission spectra to the Beer-Lambert absorption law for the dioctyl phthalate (DEHP) photodeposit. (Ultraviolet wavelength range)

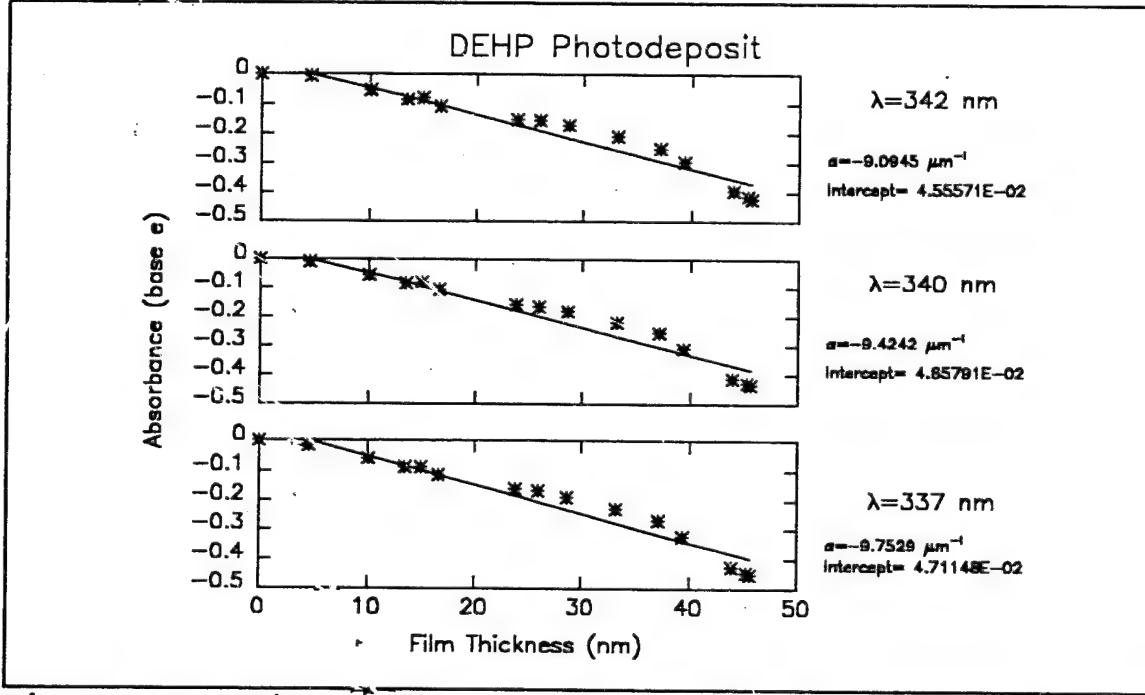


Figure C14h Fits of the measured transmission spectra to the Beer-Lambert absorption law for the dioctyl phthalate (DEHP) photodeposit. (Ultraviolet wavelength range)

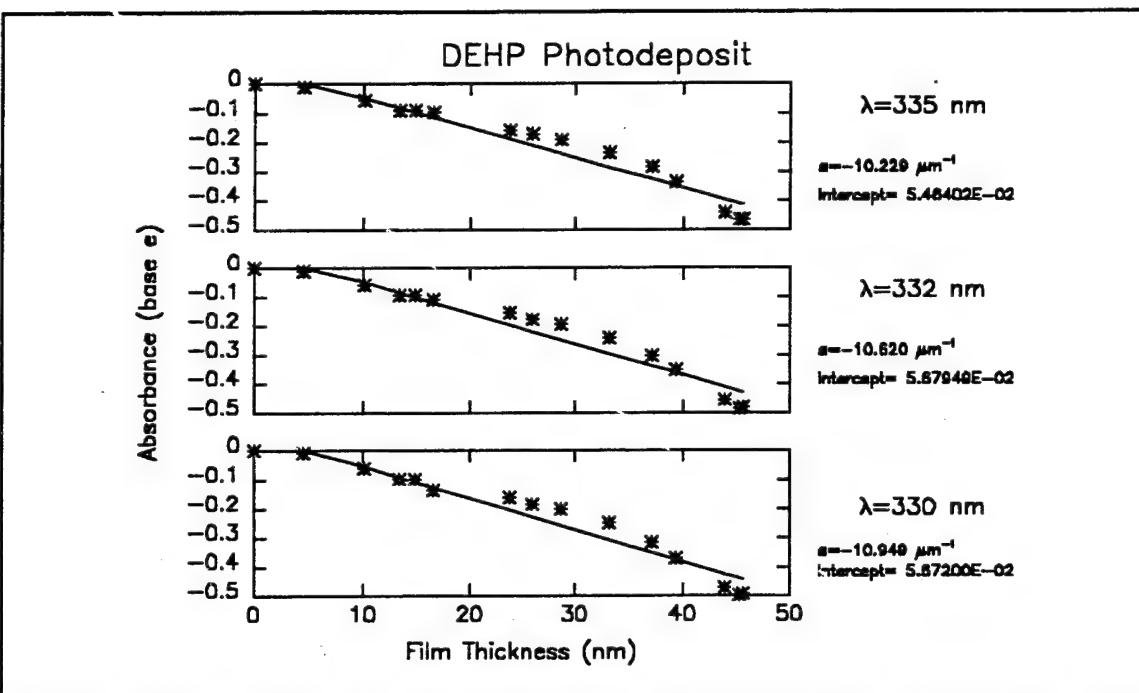


Figure C14i Fits of the measured transmission spectra to the Beer-Lambert absorption law for the dioctyl phthalate (DEHP) photodeposit. (Ultraviolet wavelength range)

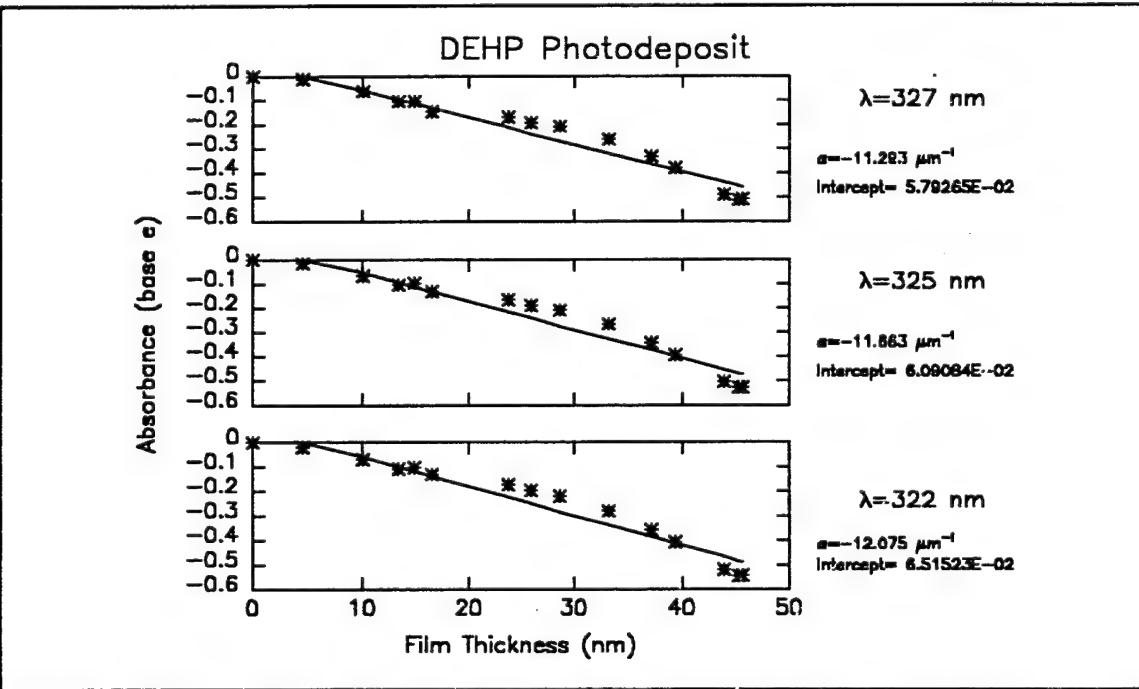


Figure C14j Fits of the measured transmission spectra to the Beer-Lambert absorption law for the dioctyl phthalate (DEHP) photodeposit. (Ultraviolet wavelength range)

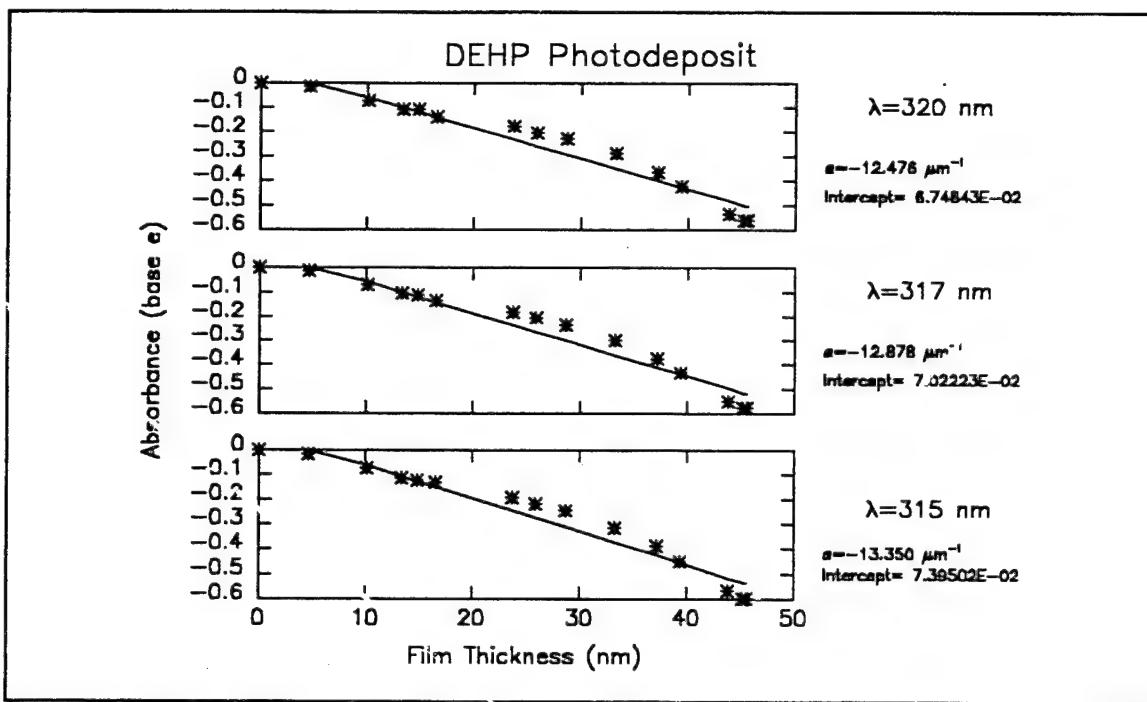


Figure C14k Fits of the measured transmission spectra to the Beer-Lambert absorption law for the dioctyl phthalate (DEHP) photodeposit. (Ultraviolet wavelength range)

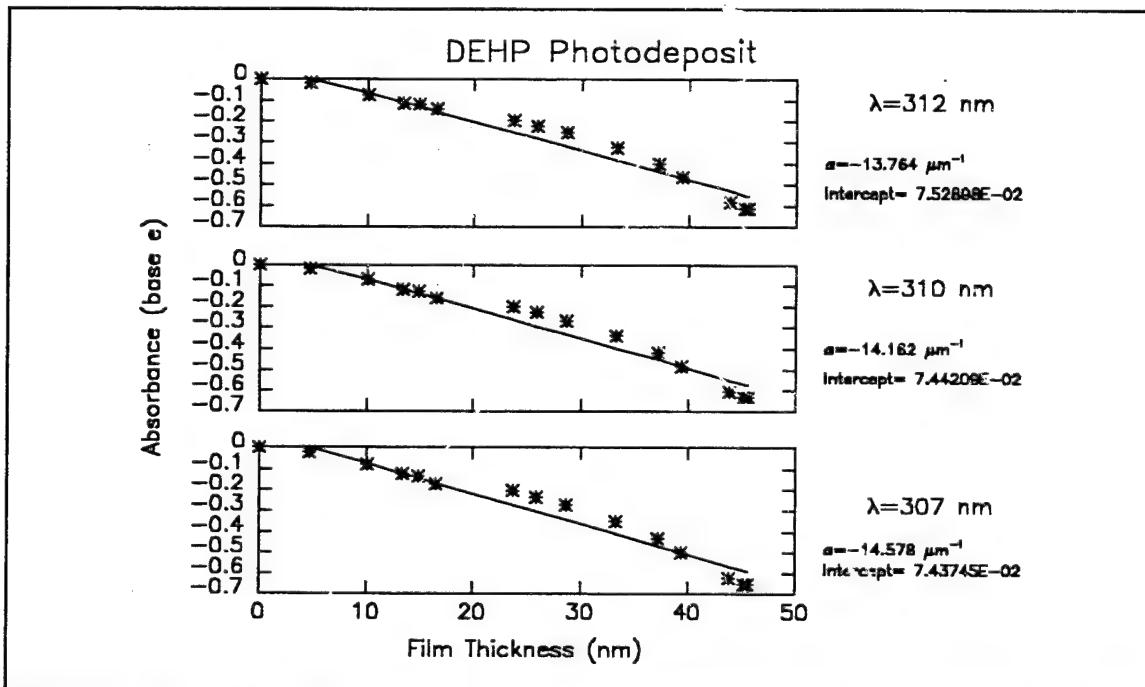


Figure C14l Fits of the measured transmission spectra to the Beer-Lambert absorption law for the dioctyl phthalate (DEHP) photodeposit. (Ultraviolet wavelength range)

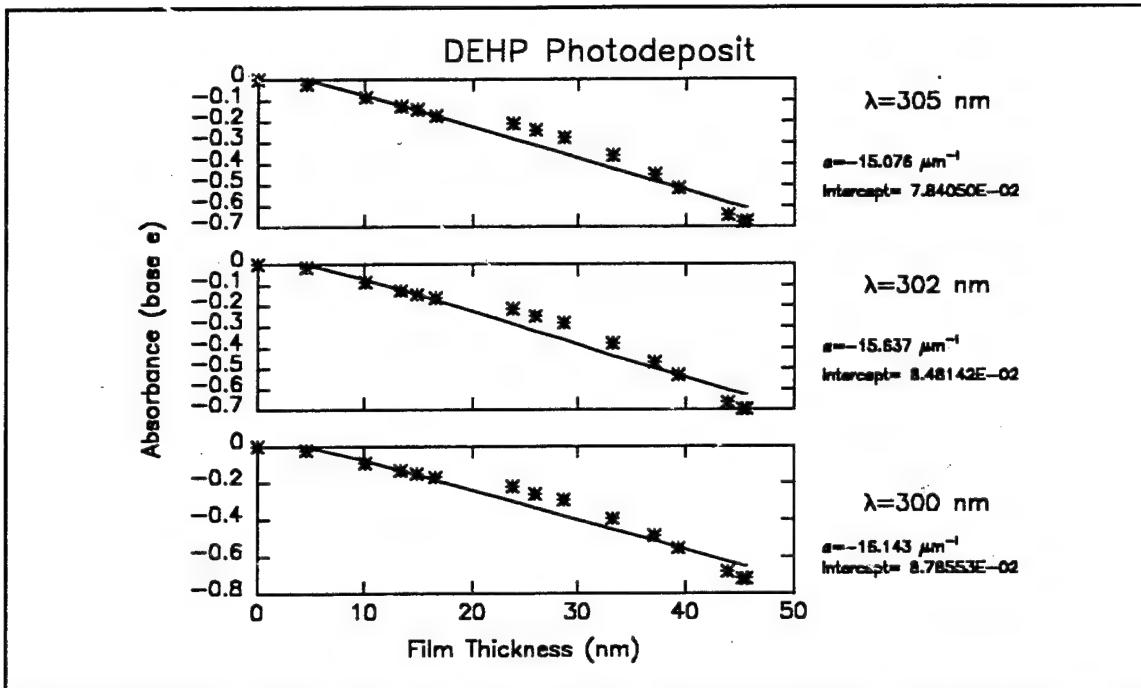


Figure C14m Fits of the measured transmission spectra to the Beer-Lambert absorption law for the dioctyl phthalate (DEHP) photodeposit. (Ultraviolet wavelength range)

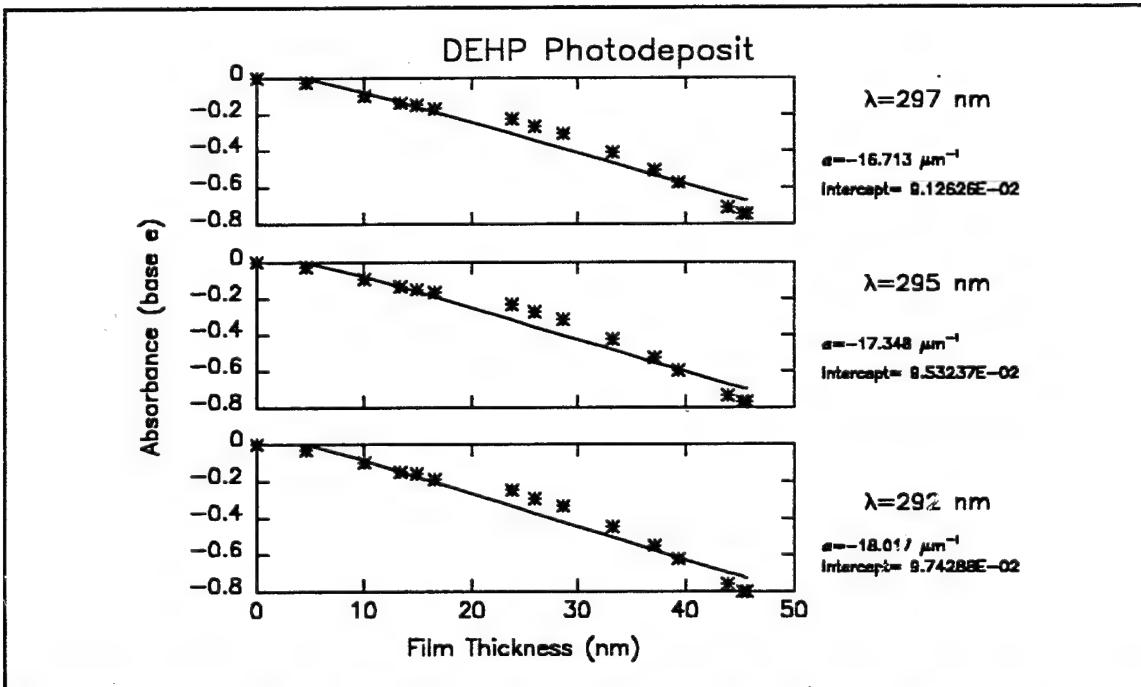


Figure C14n Fits of the measured transmission spectra to the Beer-Lambert absorption law for the dioctyl phthalate (DEHP) photodeposit. (Ultraviolet wavelength range)

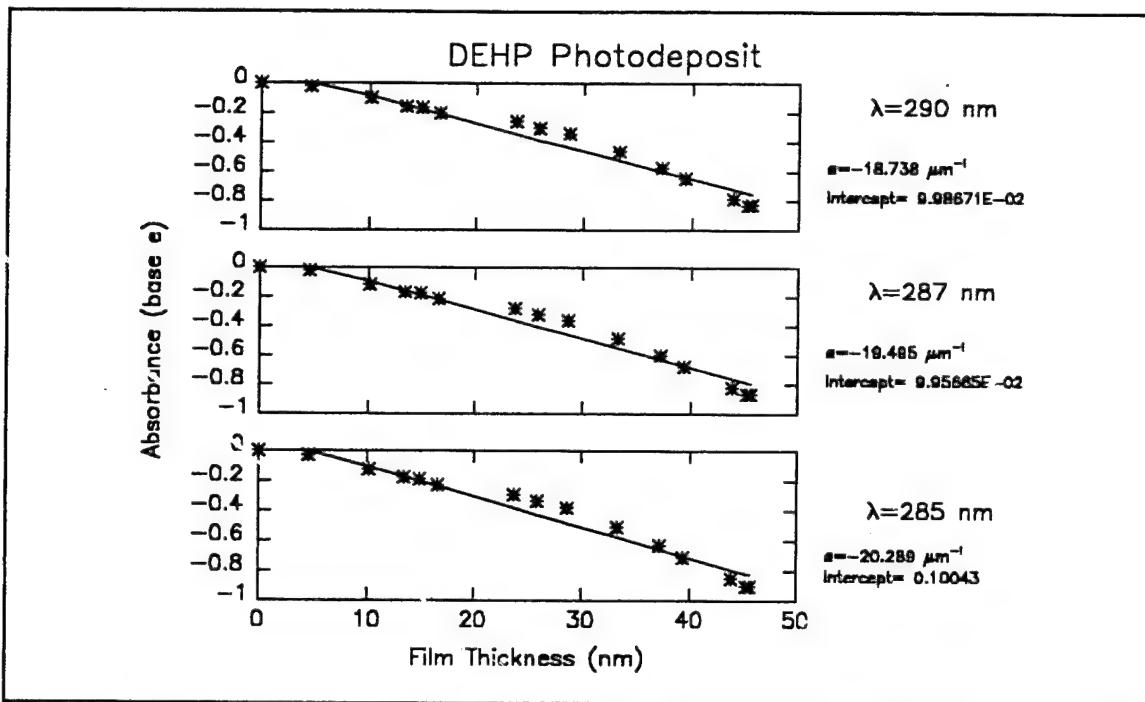


Figure C14o Fits of the measured transmission spectra to the Beer-Lambert absorption law for the dioctyl phthalate (DEHP) photodeposit. (Ultraviolet wavelength range)

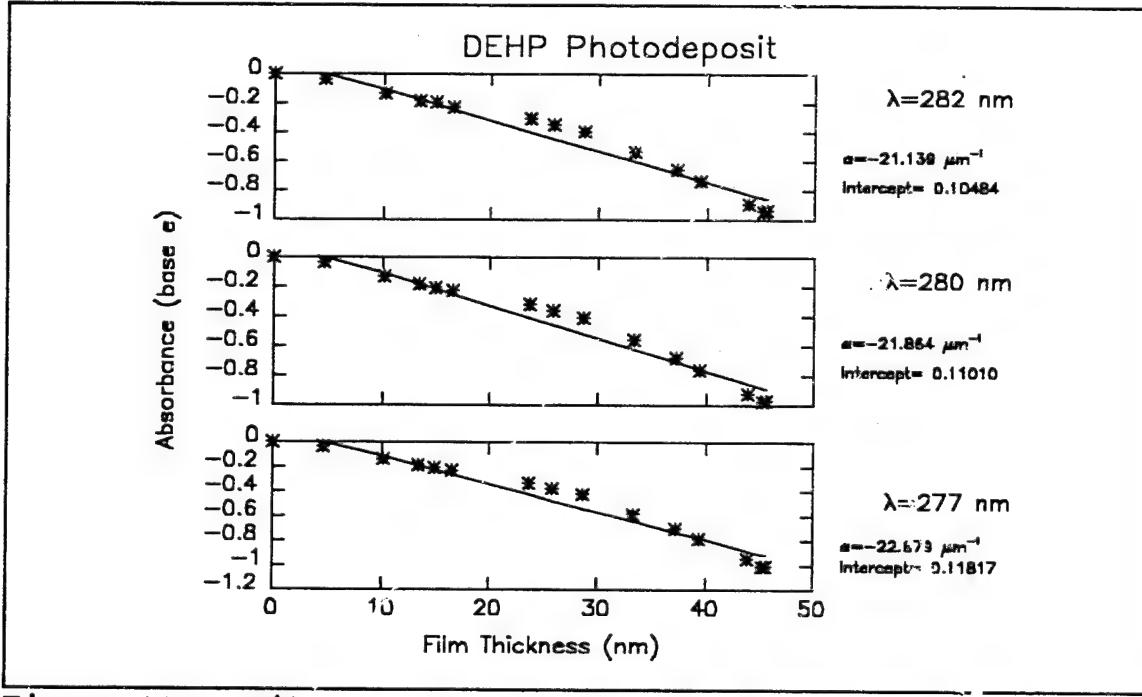


Figure C14p Fits of the measured transmission spectra to the Beer-Lambert absorption law for the dioctyl phthalate (DEHP) photodeposit. (Ultraviolet wavelength range)

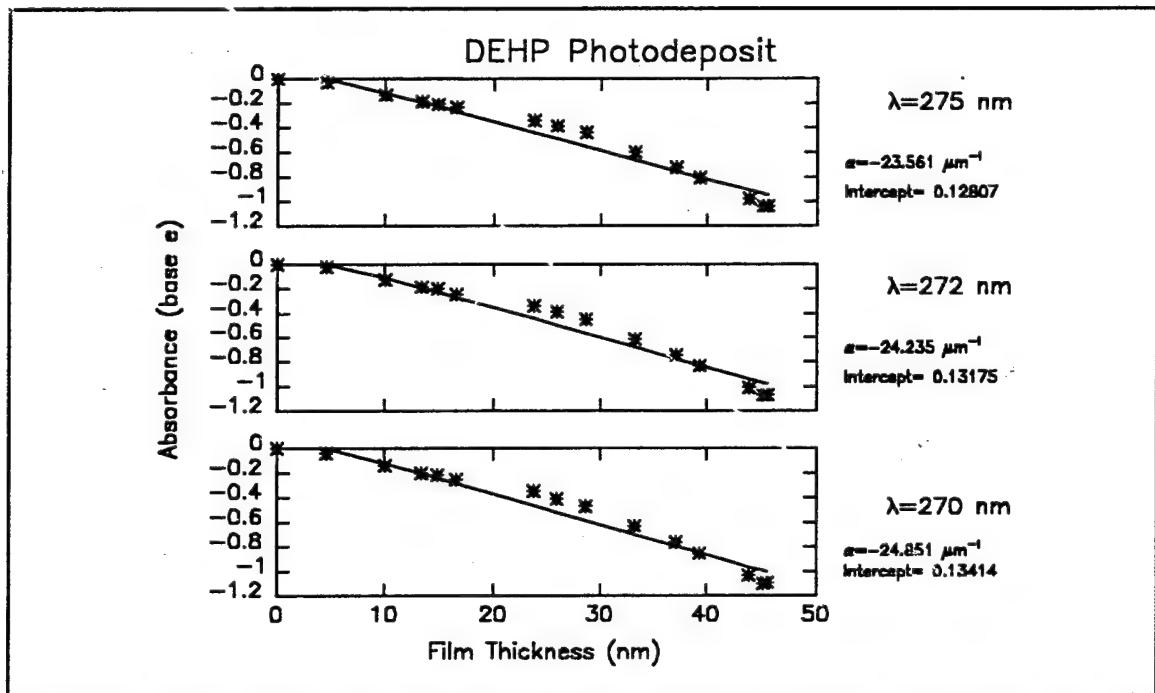


Figure C14q Fits of the measured transmission spectra to the Beer-Lambert absorption law for the dioctyl phthalate (DEHP) photodeposit. (Ultraviolet wavelength range)

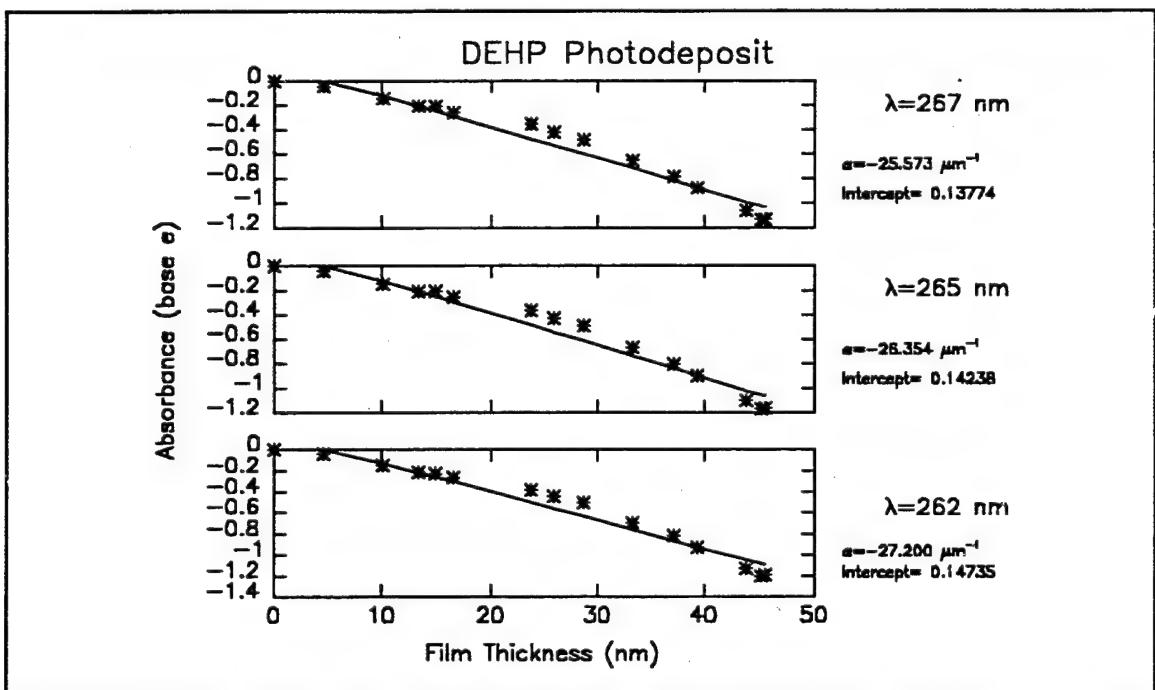


Figure C14r Fits of the measured transmission spectra to the Beer-Lambert absorption law for the dioctyl phthalate (DEHP) photodeposit. (Ultraviolet wavelength range)

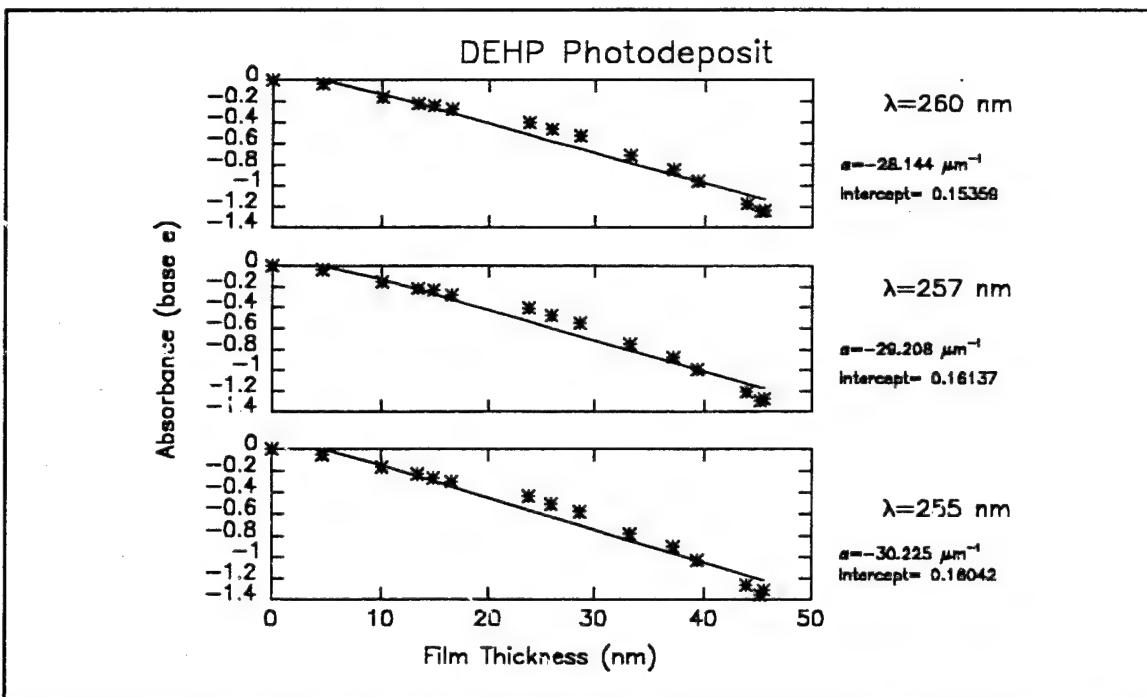


Figure C14s Fits of the measured transmission spectra to the Beer-Lambert absorption law for the dicetyl phthalate (DEHP) photodeposit. (Ultraviolet wavelength range)

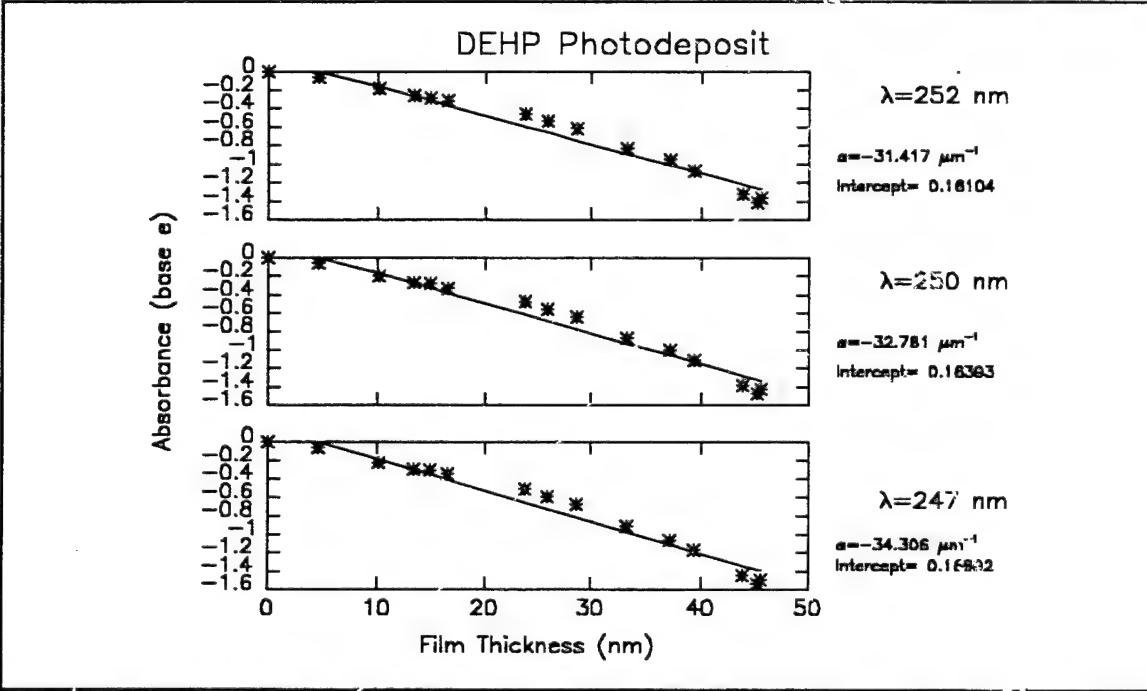


Figure C14t Fits of the measured transmission spectra to the Beer-Lambert absorption law for the dioctyl phthalate (DEHP) photodeposit. (Ultraviolet wavelength range)

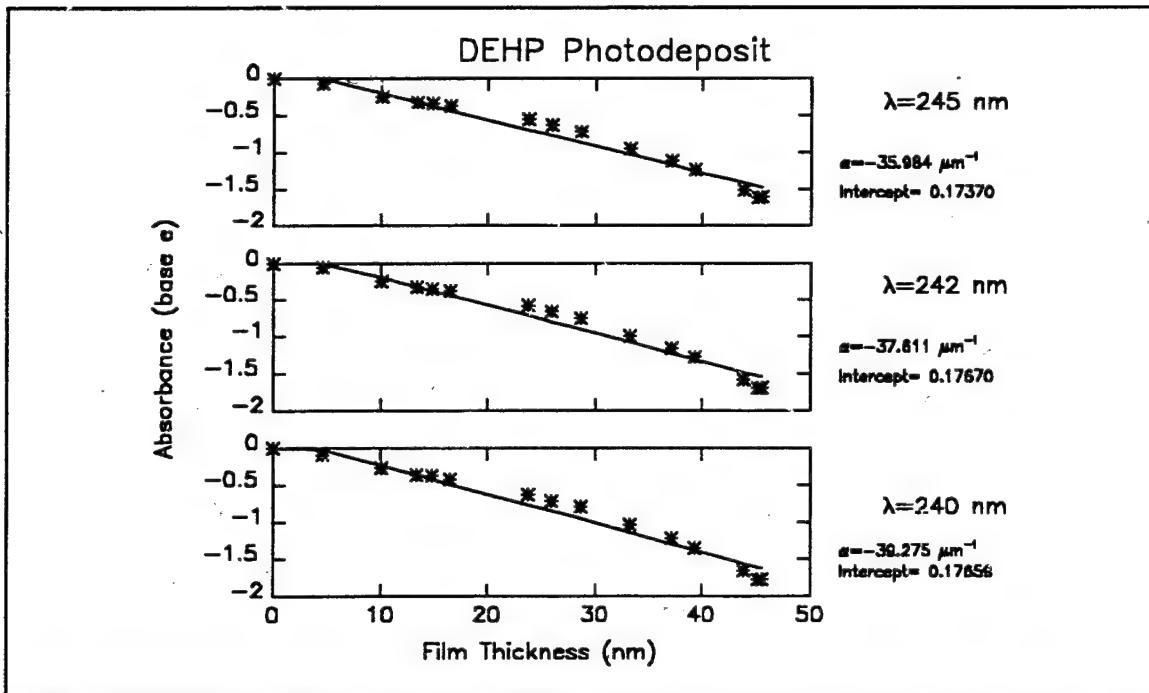


Figure C14u Fits of the measured transmission spectra to the Beer-Lambert absorption law for the dioctyl phthalate (DEHP) photodeposit. (Ultraviolet wavelength range)

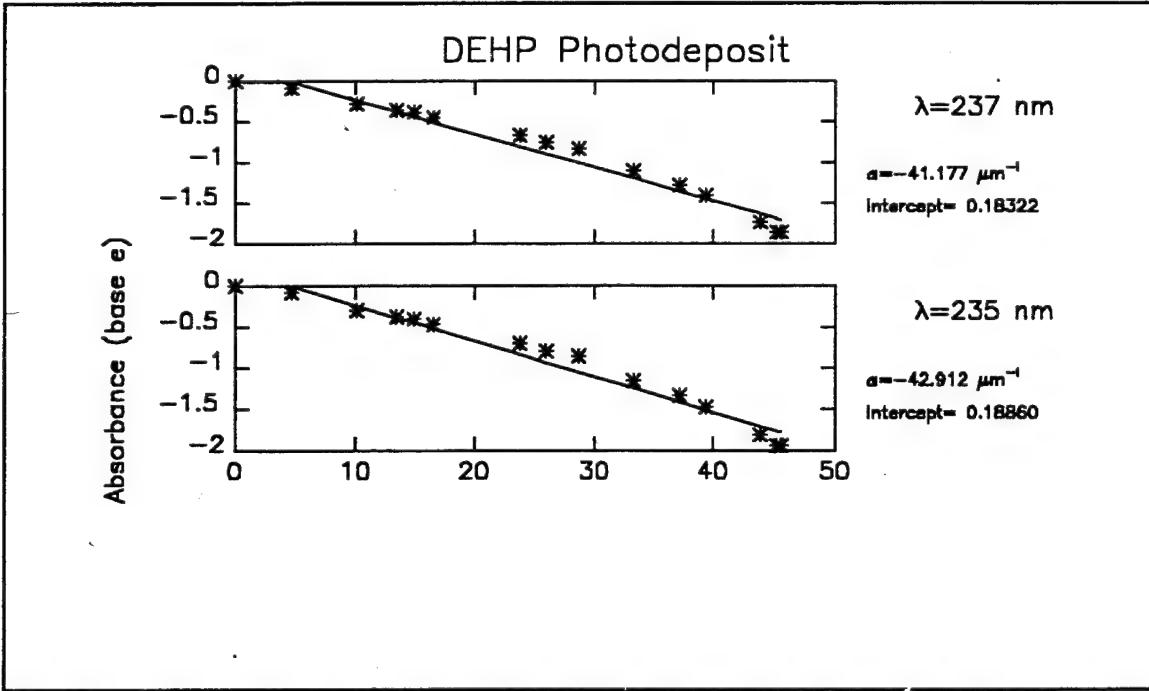


Figure C14v Fits of the measured transmission spectra to the Beer-Lambert absorption law for the dioctyl phthalate (DEHP) photodeposit. (Ultraviolet wavelength range)

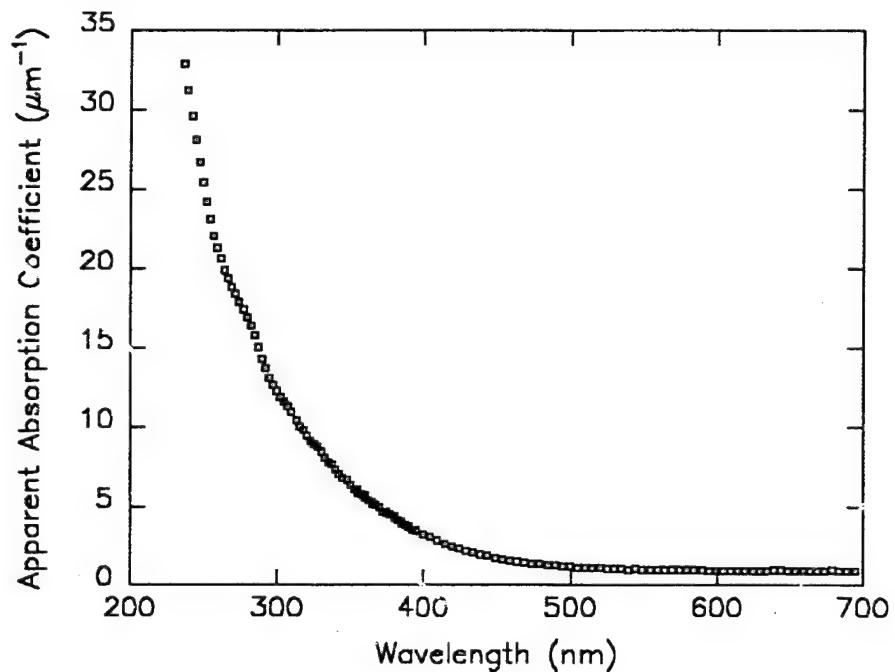


Figure C15. Apparent absorption coefficient obtained from the constrained data fits. Linear plot

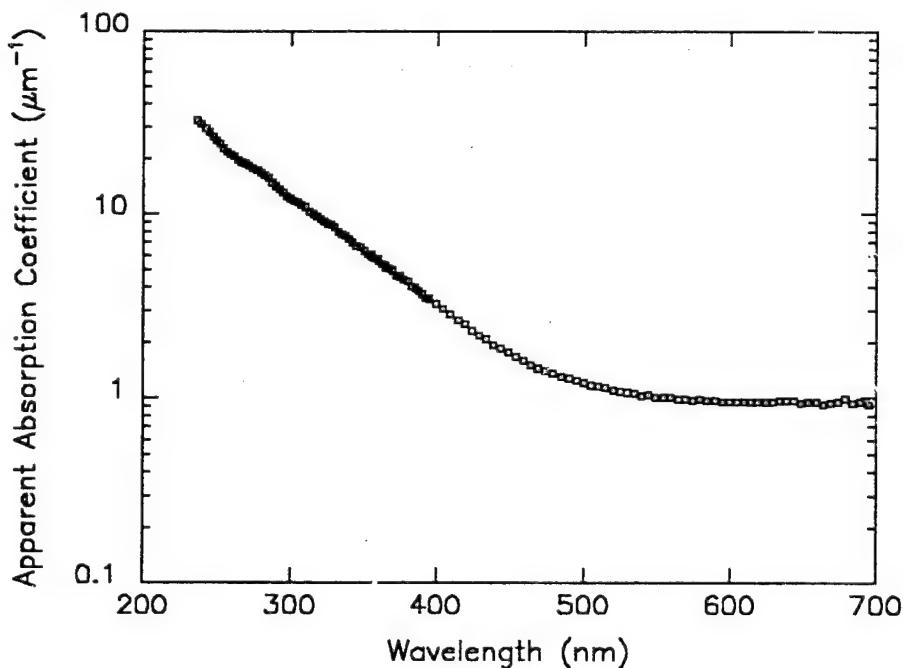


Figure C16. Apparent absorption coefficient obtained from the constrained data fits. Log plot

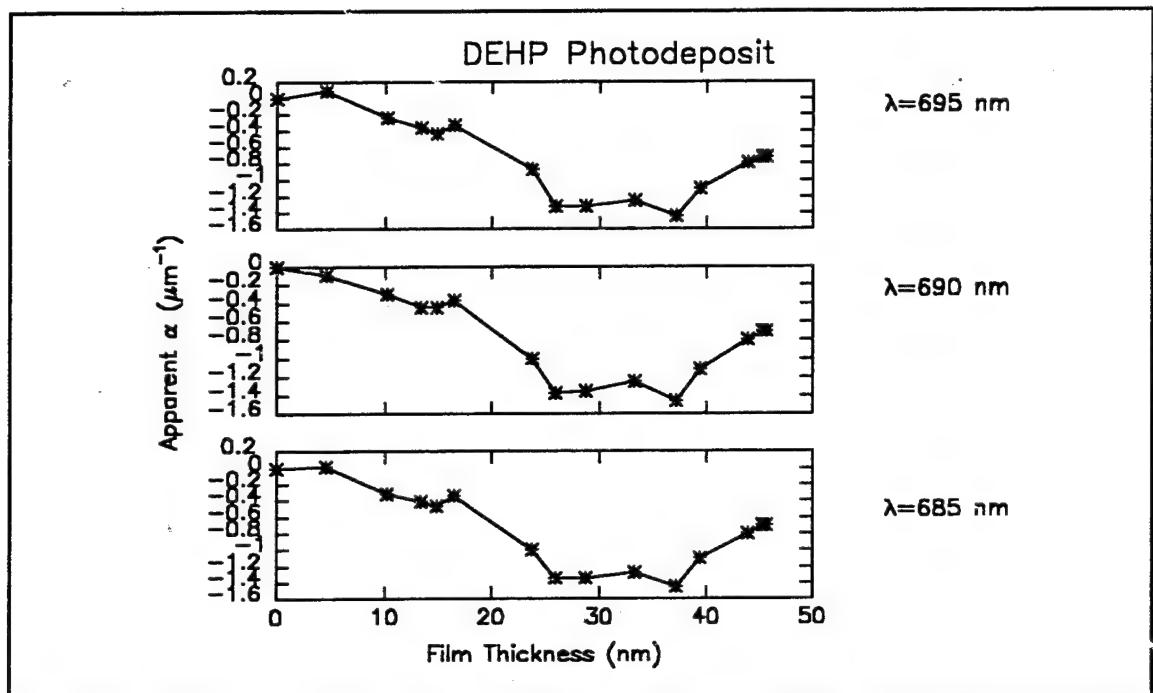


Figure C17a Computed values of α_j for photochemically deposited films of dioctyl phthalate (DEHP). (Visible wavelength range)

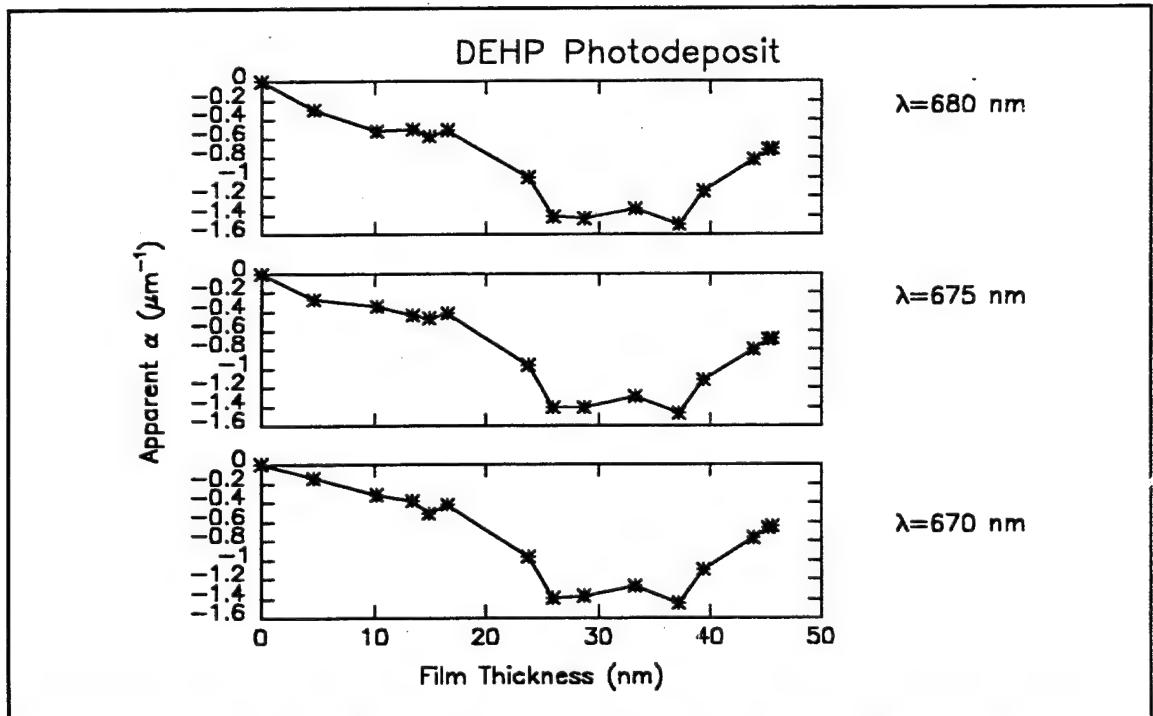


Figure C17b Computed values of α_j for photochemically deposited films of dioctyl phthalate (DEHP). (Visible wavelength range)

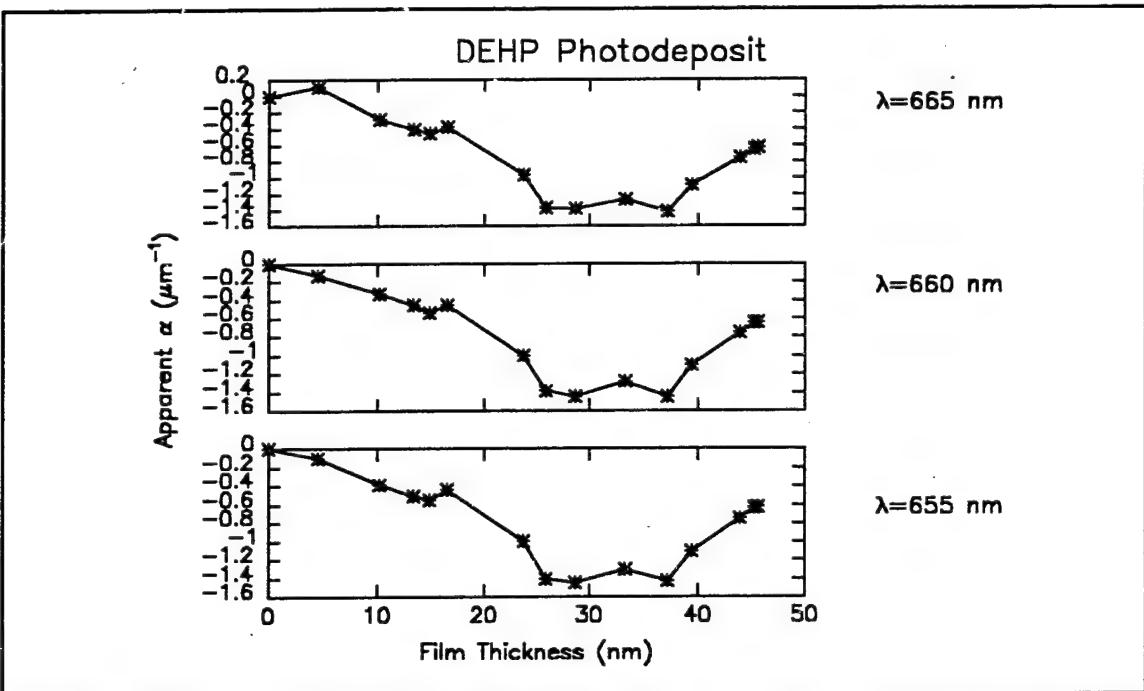


Figure C17c Computed values of α_j for photochemically deposited films of dioctyl phthalate (DEHP). (Visible wavelength range)

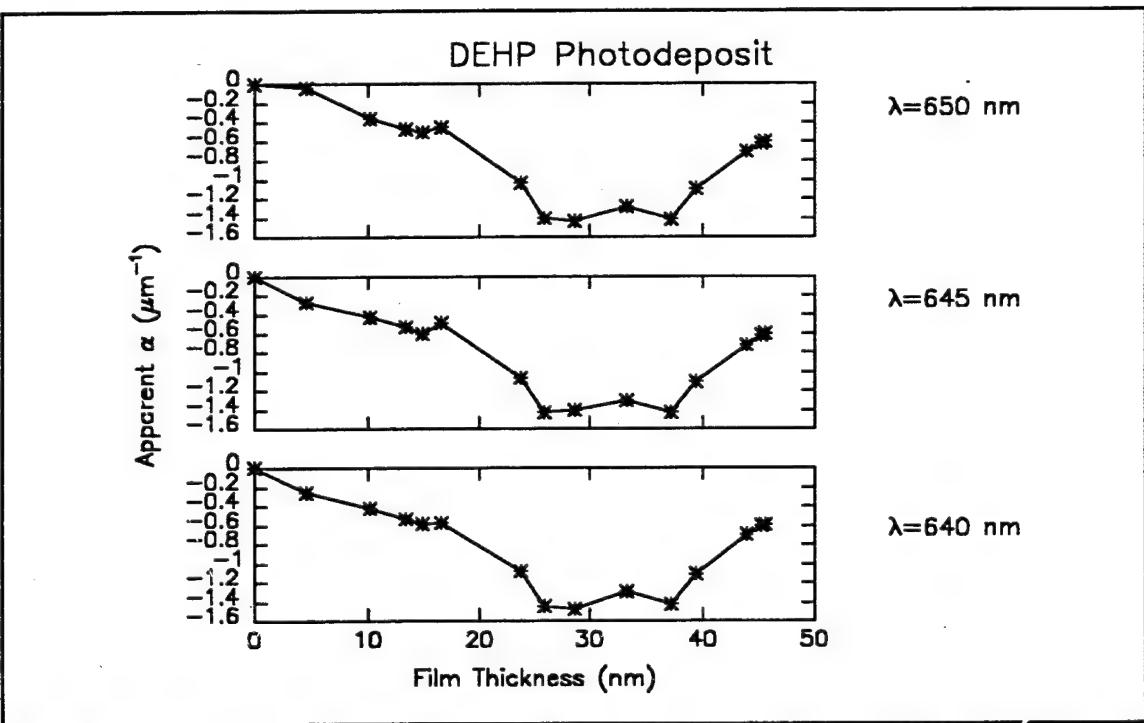


Figure C17d Computed values of α_j for photochemically deposited films of dioctyl phthalate (DEHP). (Visible wavelength range)

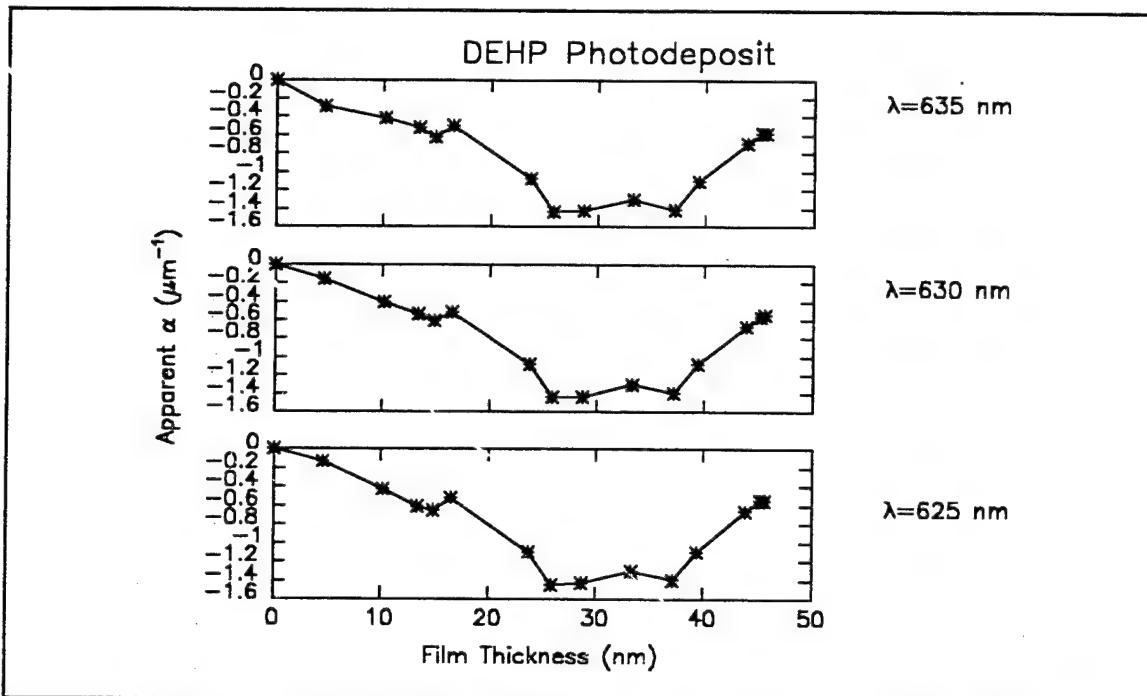


Figure C17e Computed values of α_i for photochemically deposited films of dioctyl phthalate (DEHP). (Visible wavelength range)

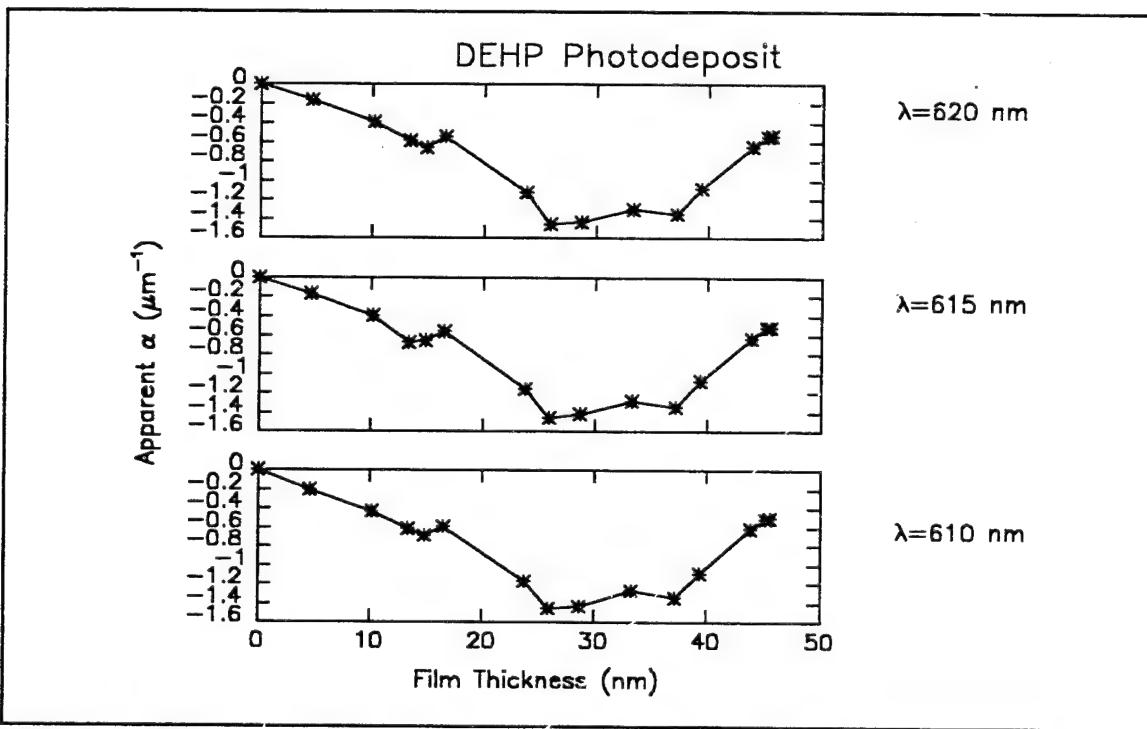


Figure C17f Computed values of α_i for photochemically deposited films of dioctyl phthalate (DEHP). (Visible wavelength range)

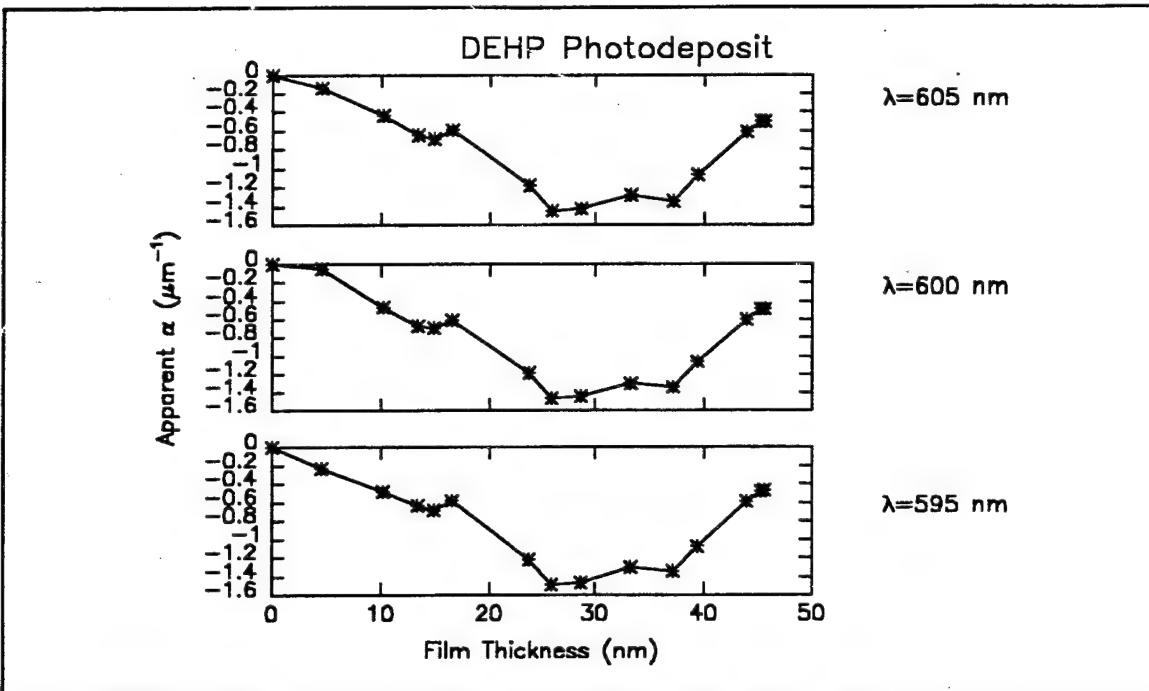


Figure C17g Computed values of α_j for photochemically deposited films of dioctyl phthalate (DEHP). (Visible wavelength range)

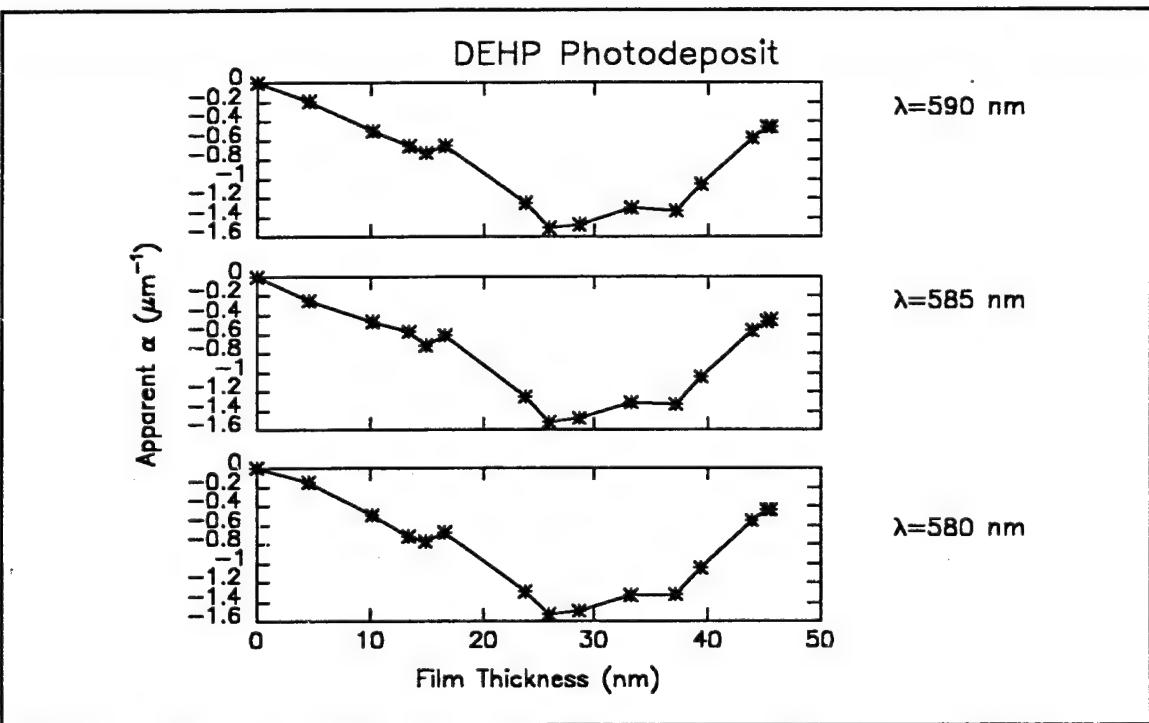


Figure C17h Computed values of α_j for photochemically deposited films of dioctyl phthalate (DEHP). (Visible wavelength range)

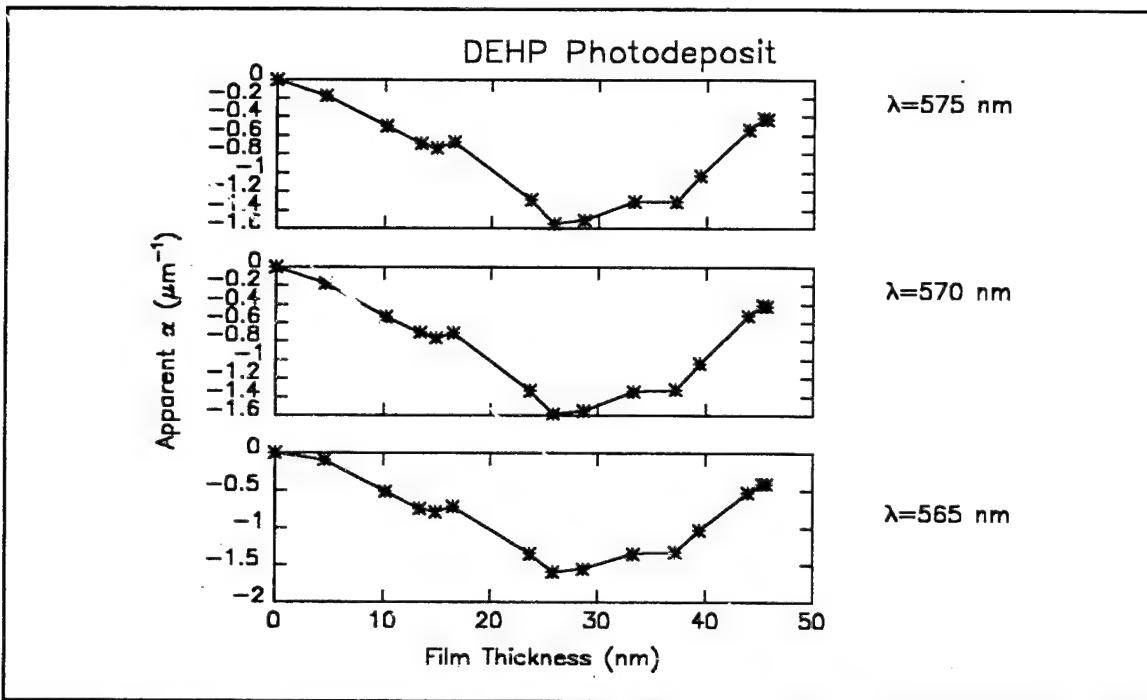


Figure C17i Computed values of α_j for photochemically deposited films of diethyl phthalate (DEHP). (Visible wavelength range)

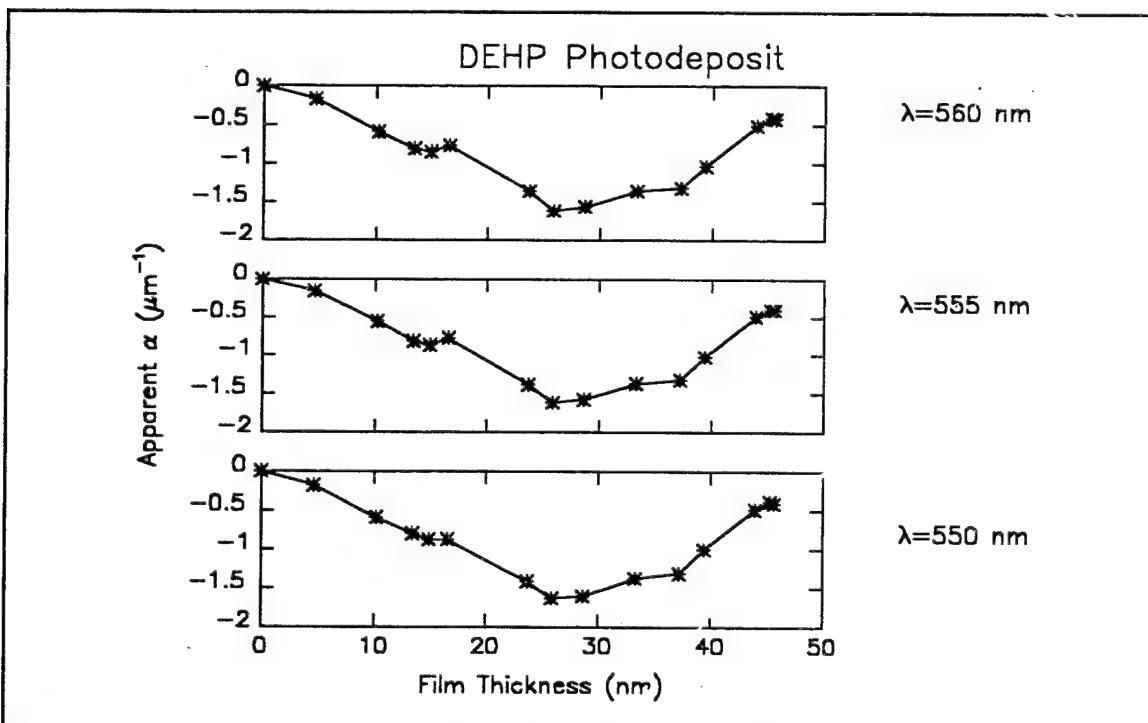


Figure C17j Computed values of α_j for photochemically deposited films of diethyl phthalate (DEHP). (Visible wavelength range)

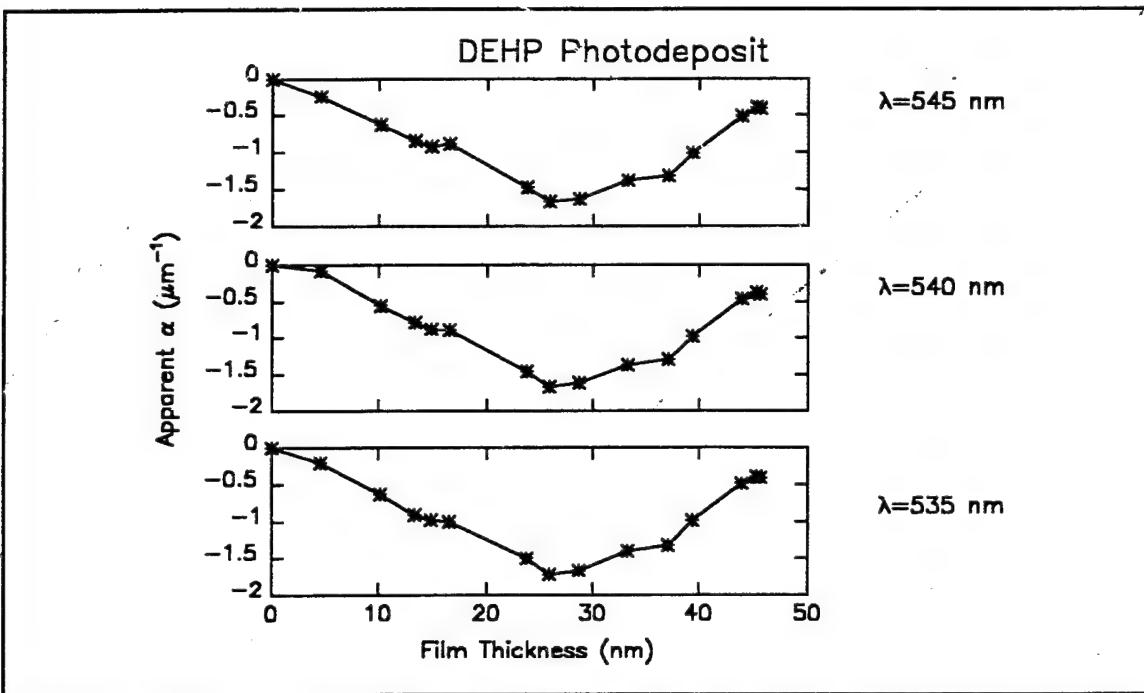


Figure C17k Computed values of α_j for photochemically deposited films of dioctyl phthalate (DEHP). (Visible wavelength range)

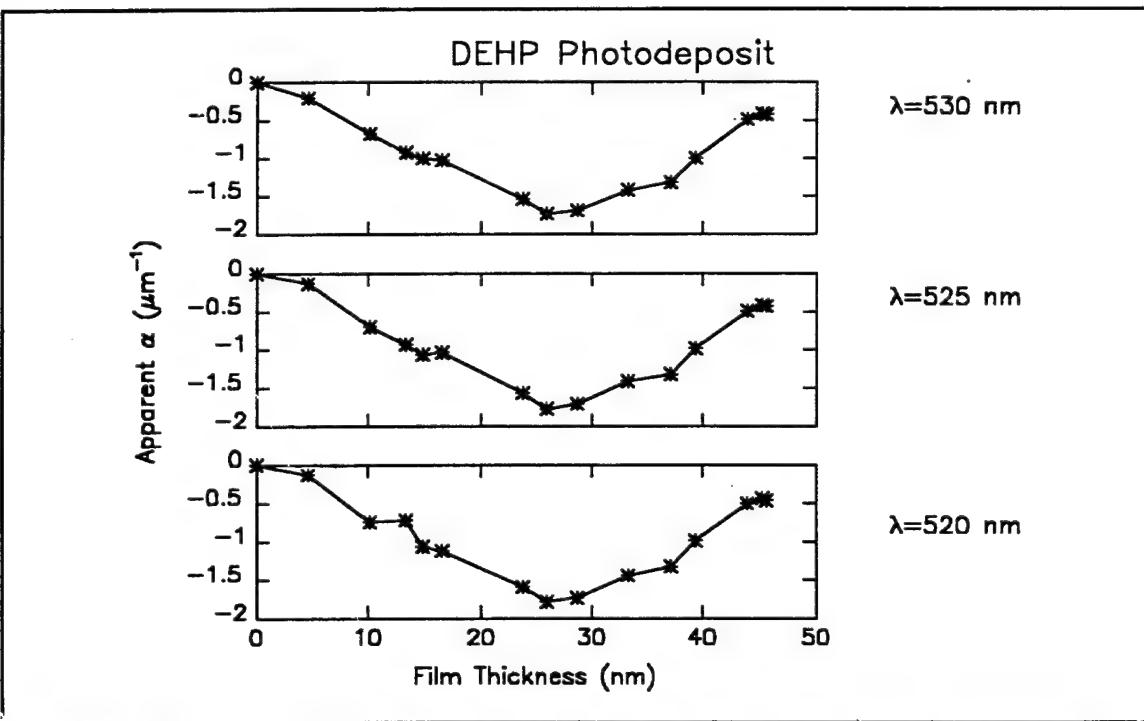


Figure C17l Computed values of α_j for photochemically deposited films of dioctyl phthalate (DEHP). (Visible wavelength range)

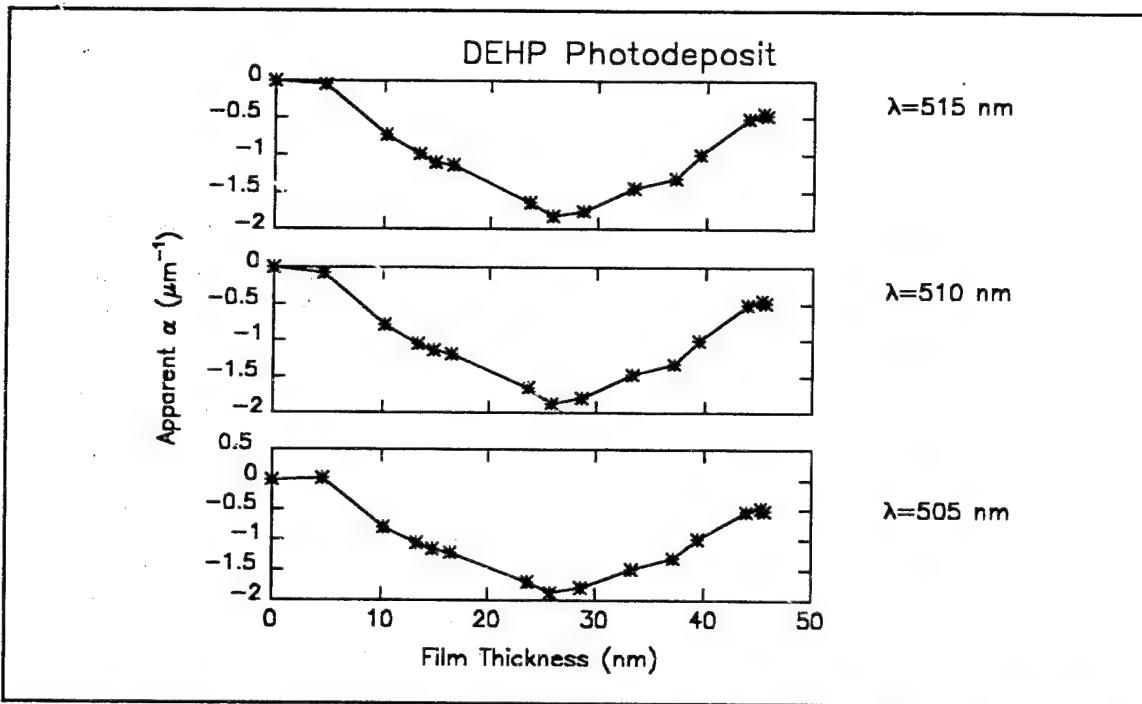


Figure C17m Computed values of α_j for photochemically deposited films of dioctyl phthalate (DEHP). (Visible wavelength range)

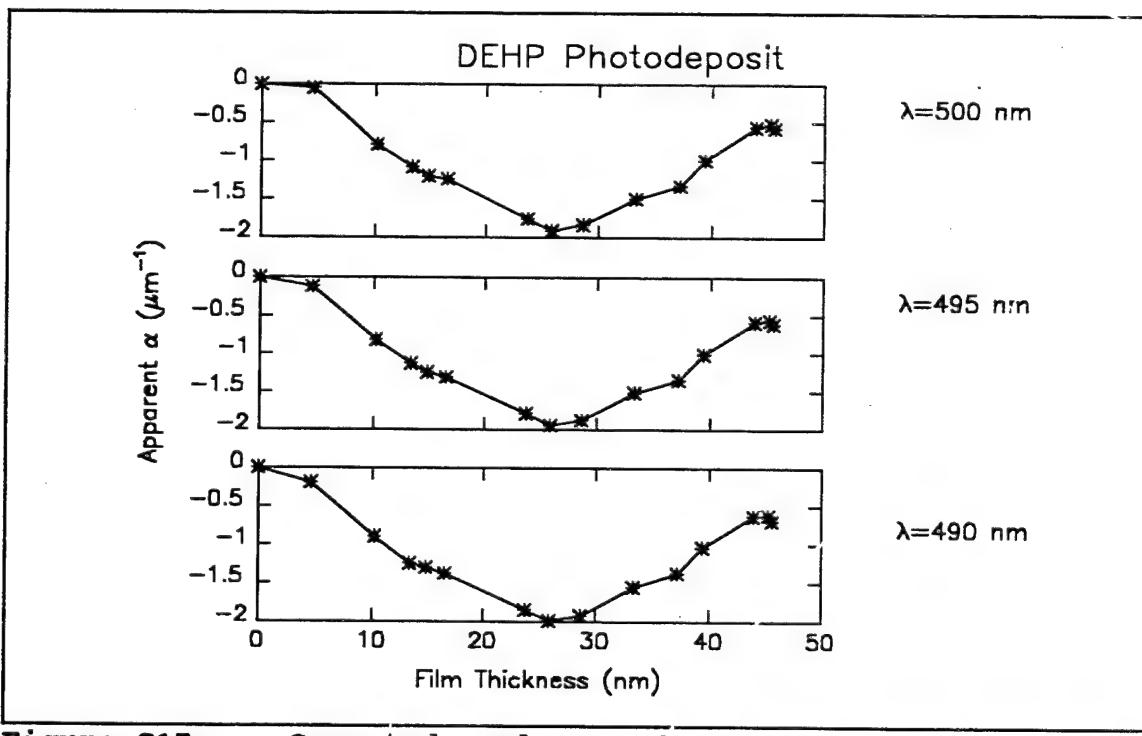


Figure C17n Computed values of α_j for photochemically deposited films of dioctyl phthalate (DEHP). (Visible wavelength range)

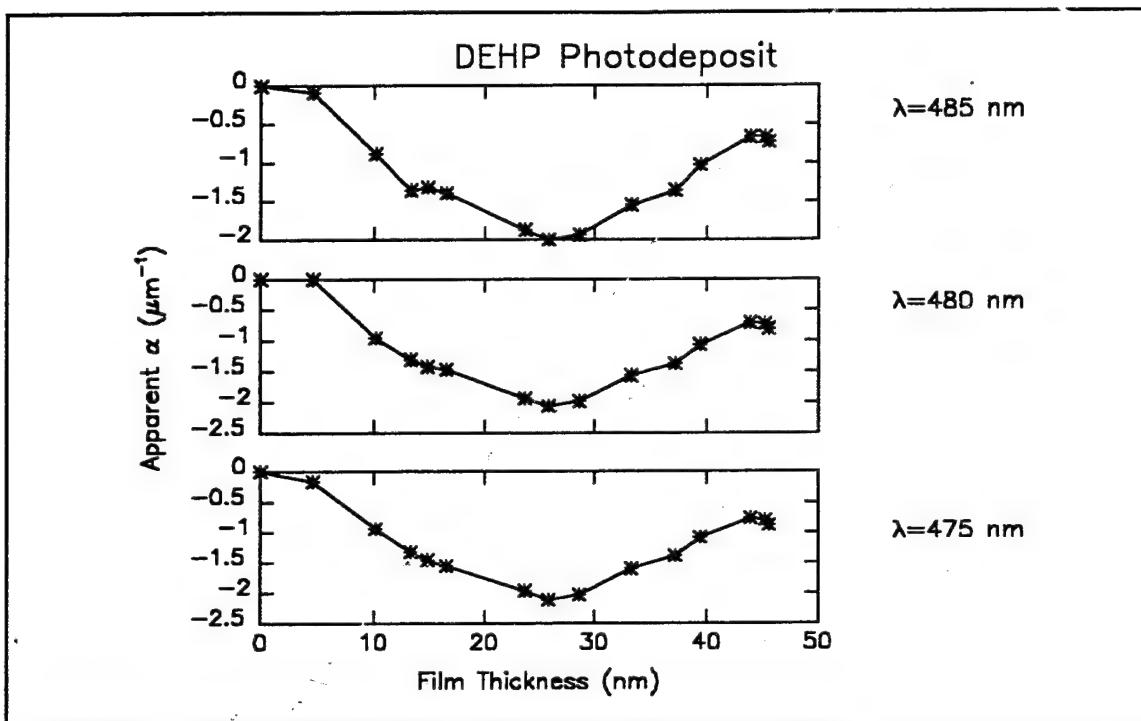


Figure C17o Computed values of α_j for photochemically deposited films of dioctyl phthalate (DEHP). (Visible wavelength range)

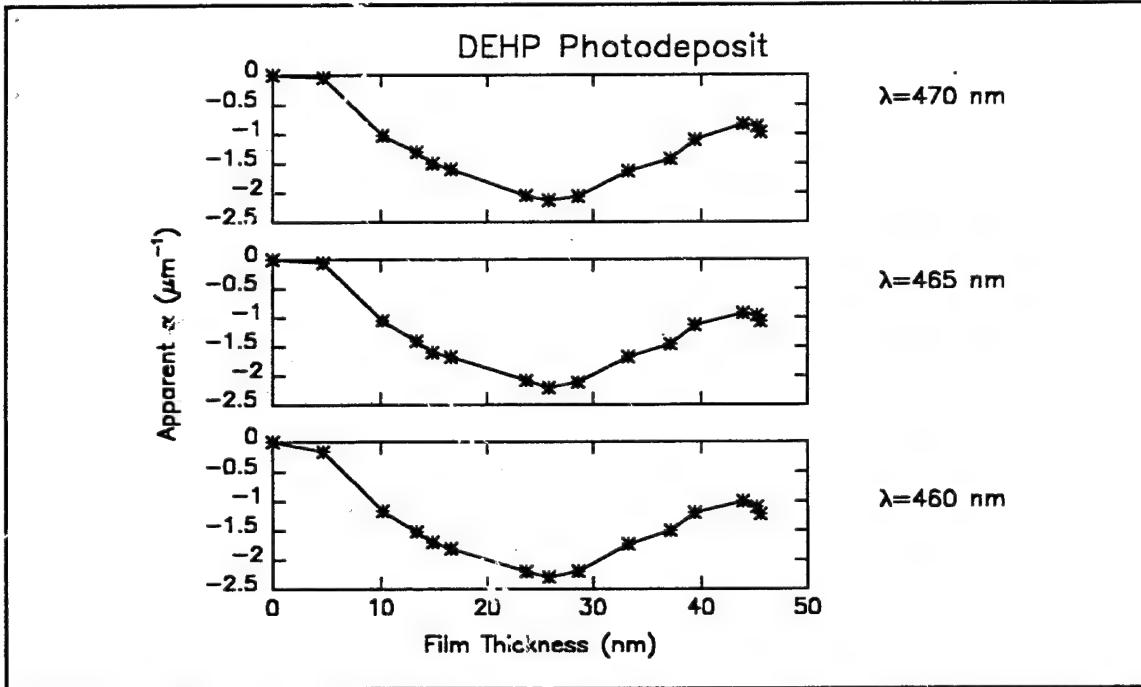


Figure C17p Computed values of α_j for photochemically deposited films of dioctyl phthalate (DEHP). (Visible wavelength range)

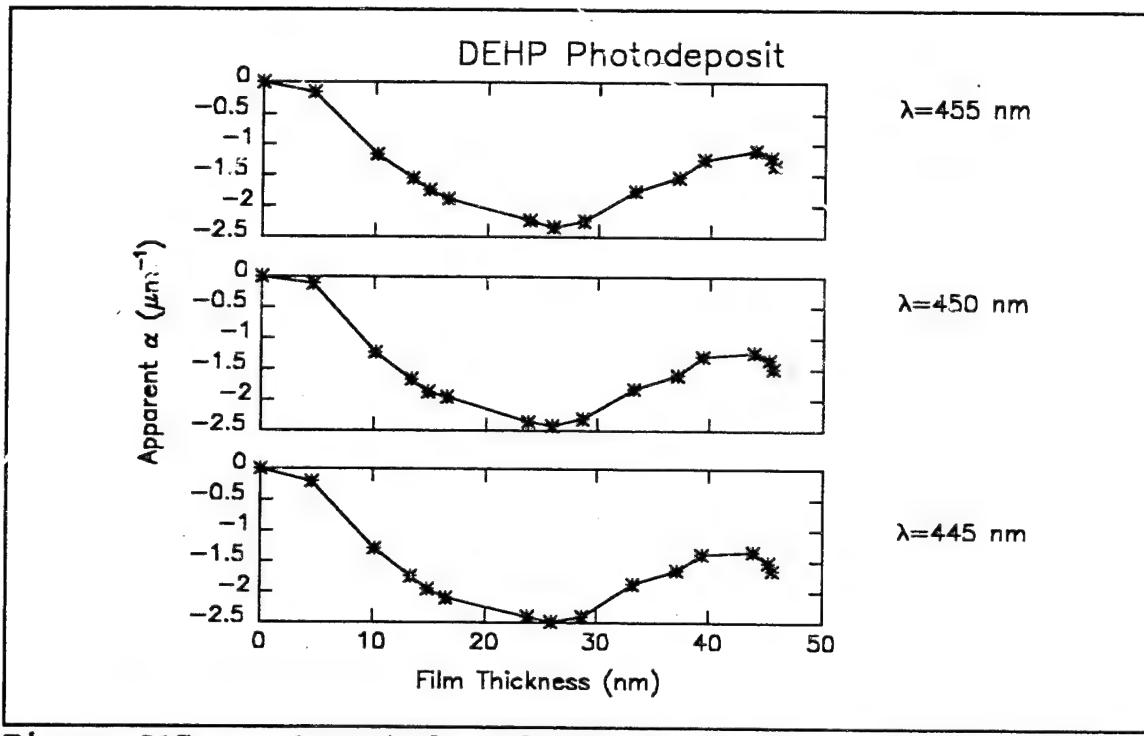


Figure C17q Computed values of α_j for photochemically deposited films of dioctyl phthalate (DEHP). (Visible wavelength range)

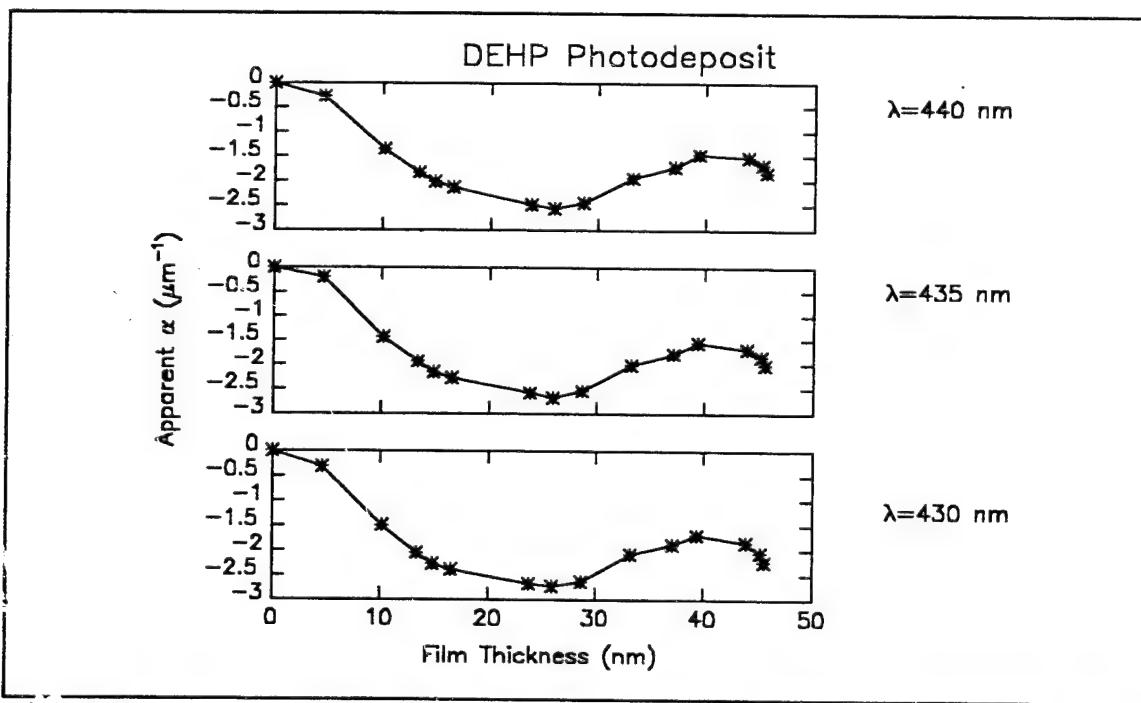


Figure C17r Computed values of α_j for photochemically deposited films of dioctyl phthalate (DEHP). (Visible wavelength range)

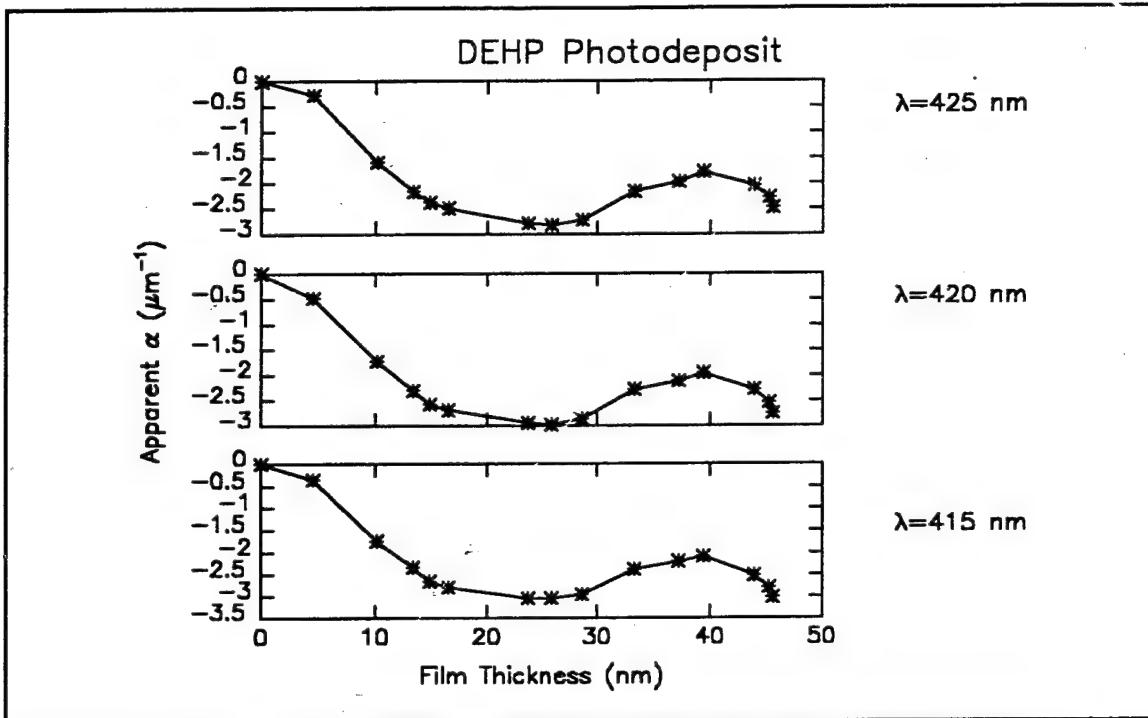


Figure C17s Computed values of α_j for photochemically deposited films of dioctyl phthalate (DEHP). (Visible wavelength range)

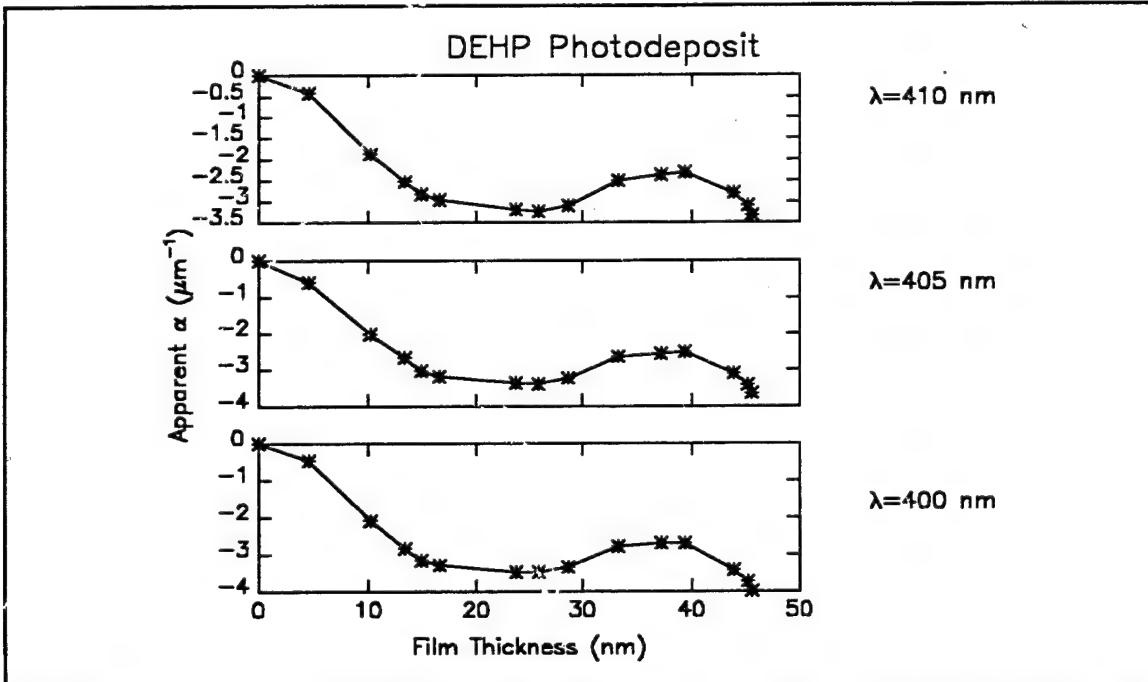


Figure C17t Computed values of α_j for photochemically deposited films of dioctyl phthalate (DEHP). (Visible wavelength range)

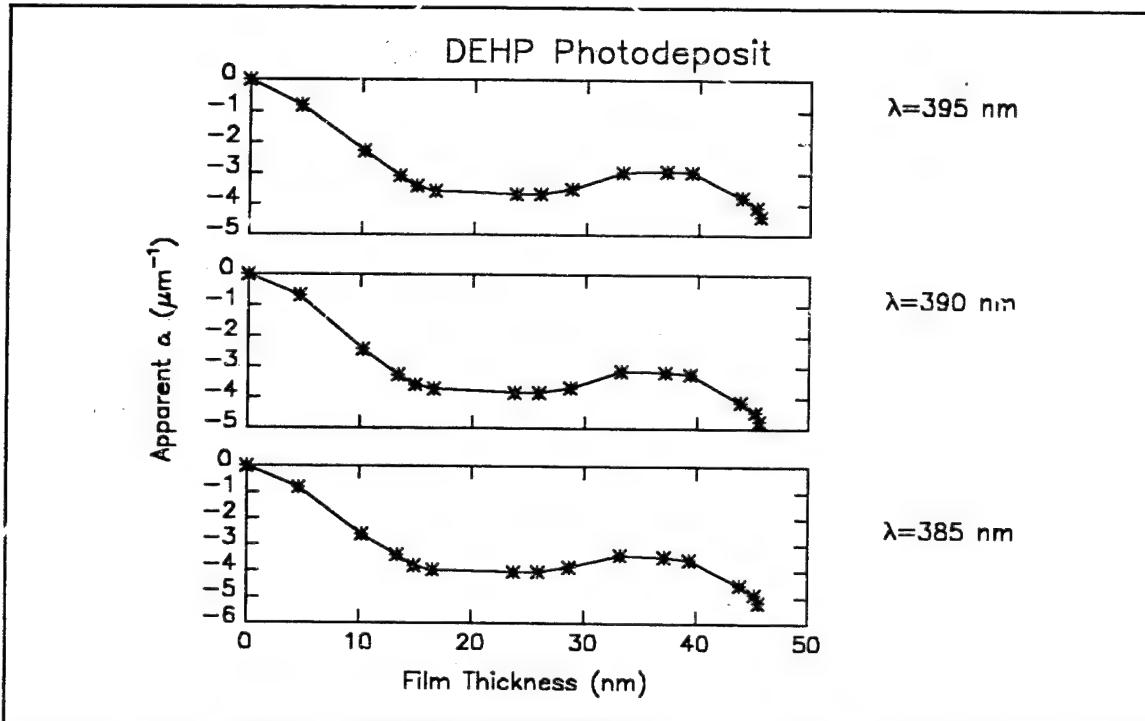


Figure C17u Computed values of α_j for photochemically deposited films of diethyl phthalate (DEHP). (Visible wavelength range)

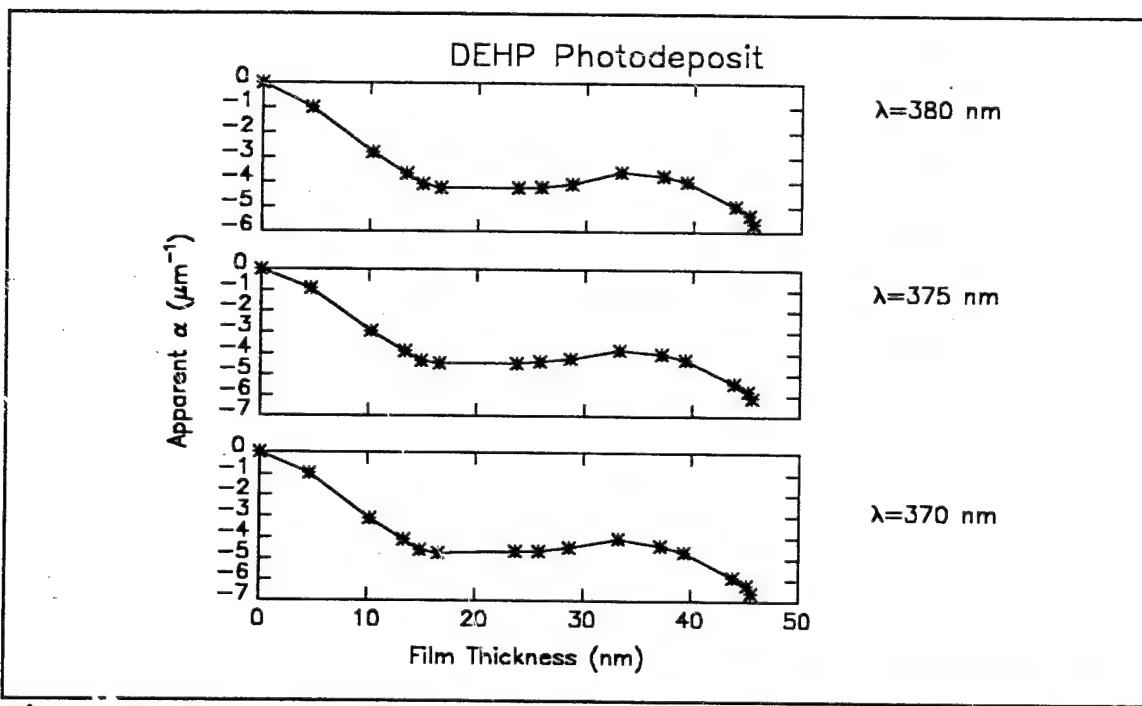


Figure C17v Computed values of α_j for photochemically deposited films of diethyl phthalate (DEHP). (Visible wavelength range)

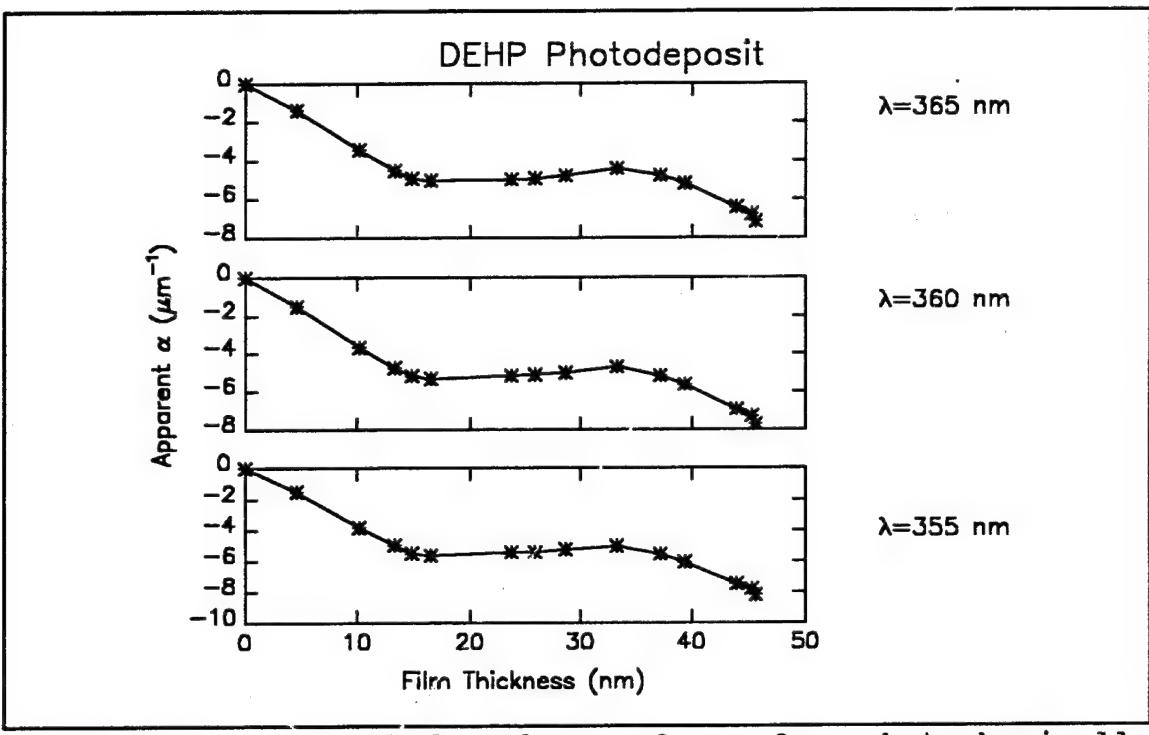


Figure C17w Computed values of α_j for photochemically deposited films of dioctyl phthalate (DEHP). (Visible wavelength range)

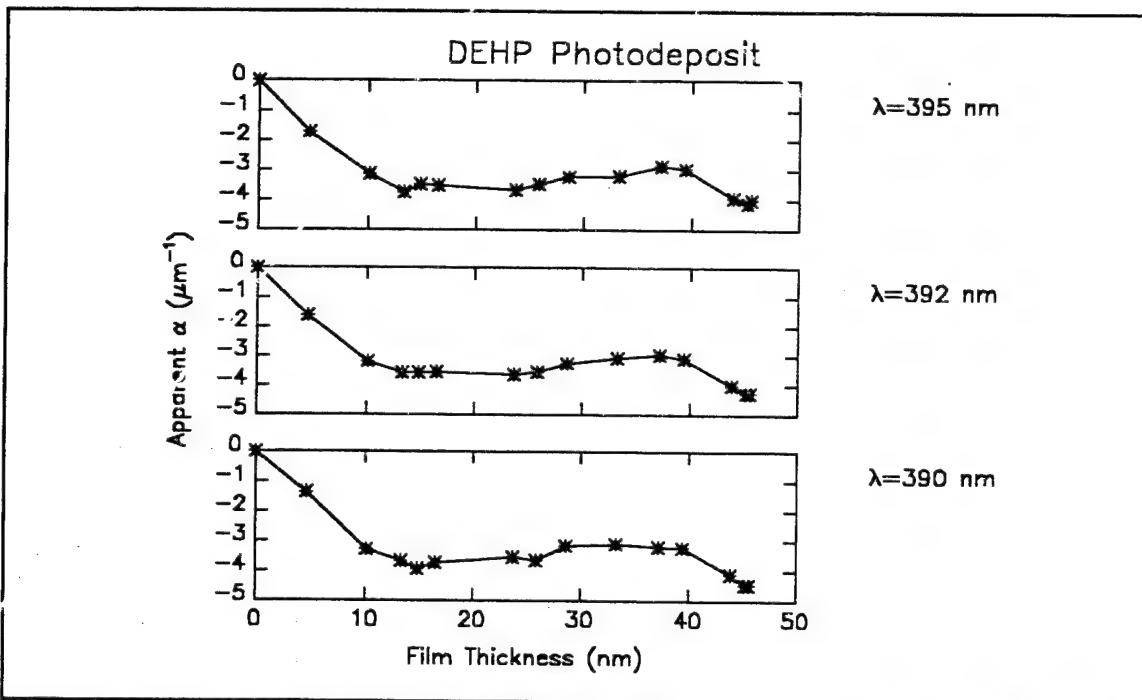


Figure C18a Computed values of α_j for photochemically deposited films of dioctyl phthalate (DEHP). (Ultraviolet wavelength range)

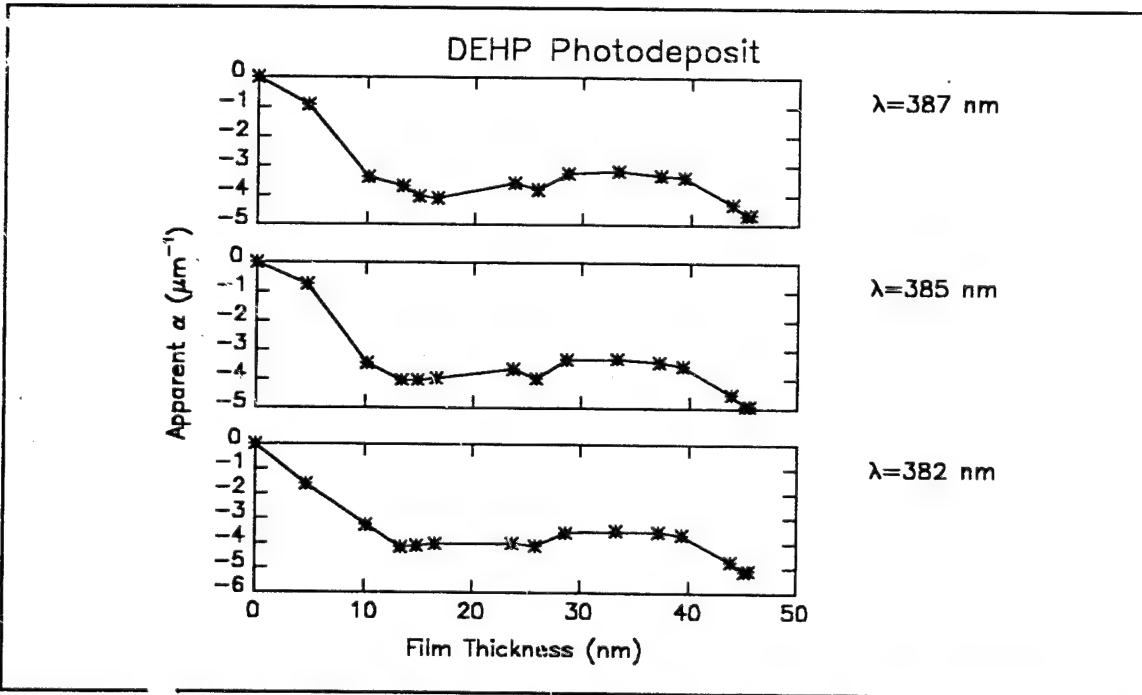


Figure C18b Computed values of α_j for photochemically deposited films of dioctyl phthalate (DEHP). (Ultraviolet wavelength range)

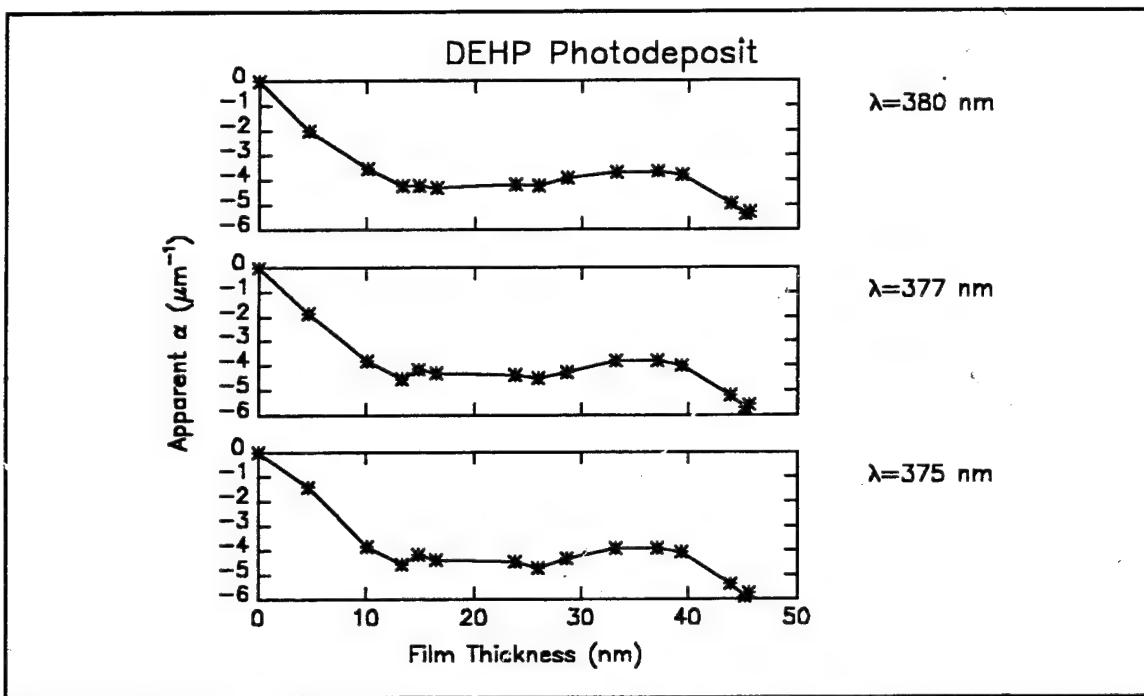


Figure C18c Computed values of α_j for photochemically deposited films of dioctyl phthalate (DEHP). (Ultraviolet wavelength range)

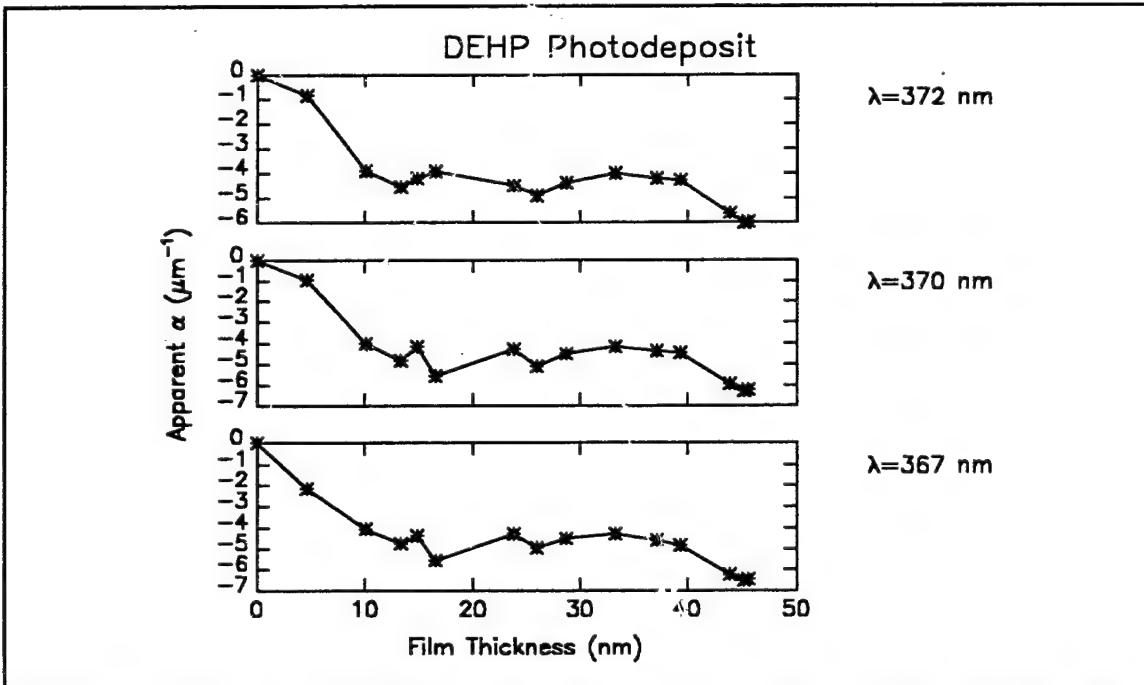


Figure C18d Computed values of ν_j for photochemically deposited films of dioctyl phthalate (DEHP). (Ultraviolet wavelength range)

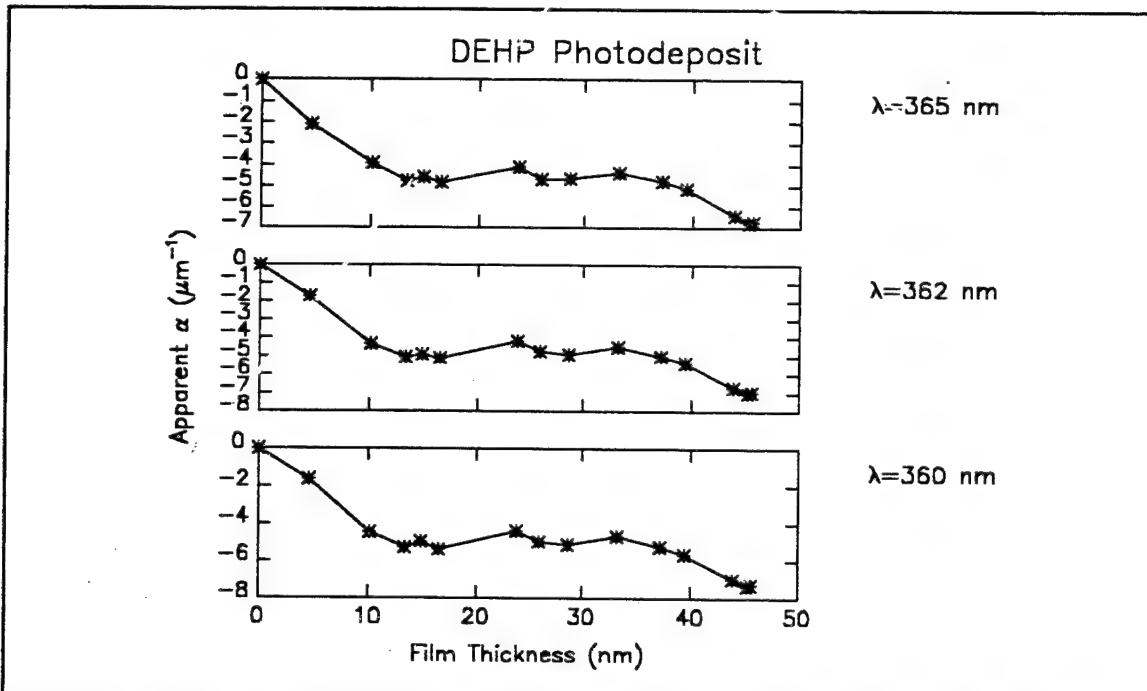


Figure C18e Computed values of α_j for photochemically deposited films of dioctyl phthalate (DEHP). (Ultraviolet wavelength range)

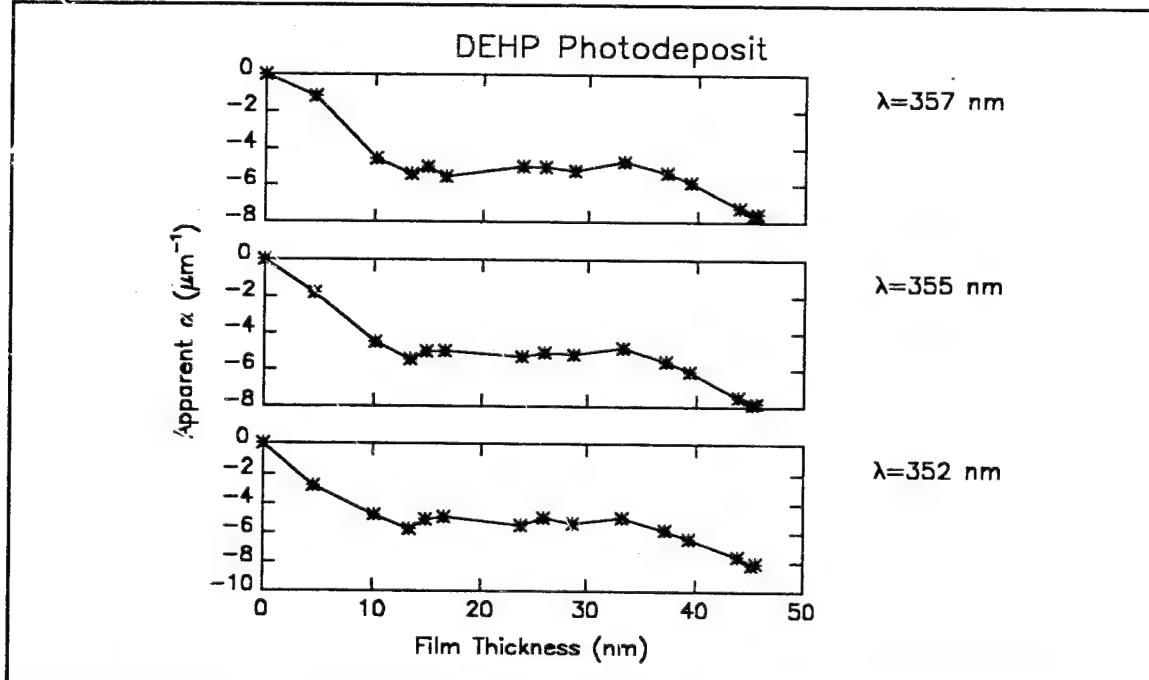


Figure C18f Computed values of α_j for photochemically deposited films of dioctyl phthalate (DEHP). (Ultraviolet wavelength range)

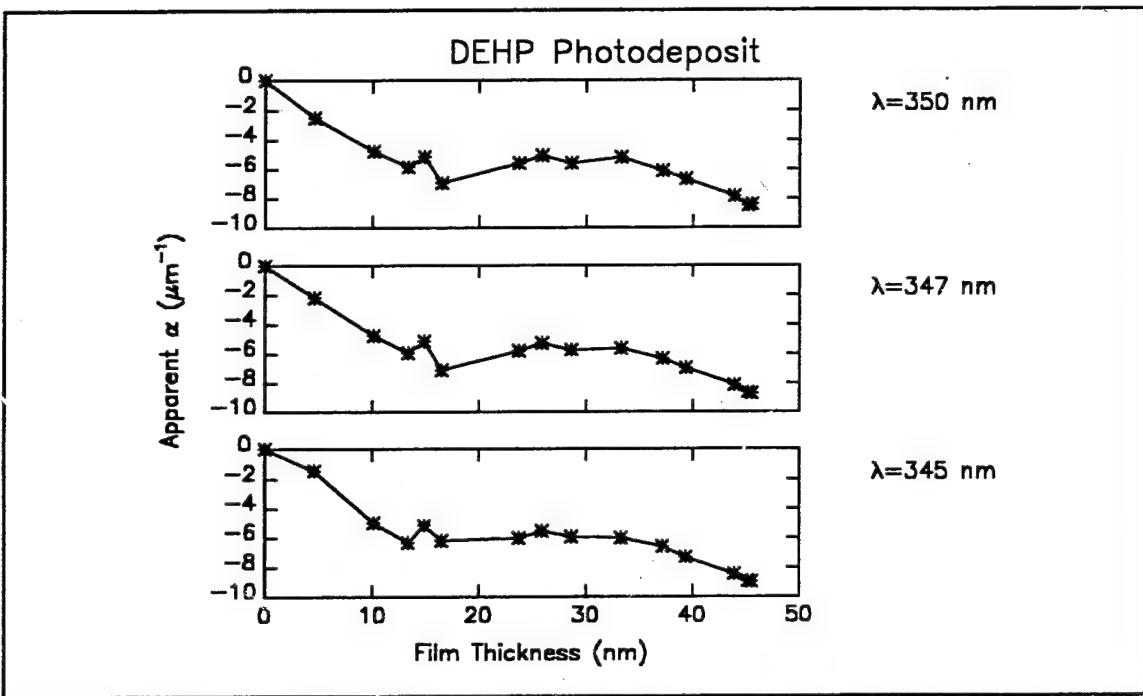


Figure C18g Computed values of α_j for photochemically deposited films of dioctyl phthalate (DEHP). (Ultraviolet wavelength range)

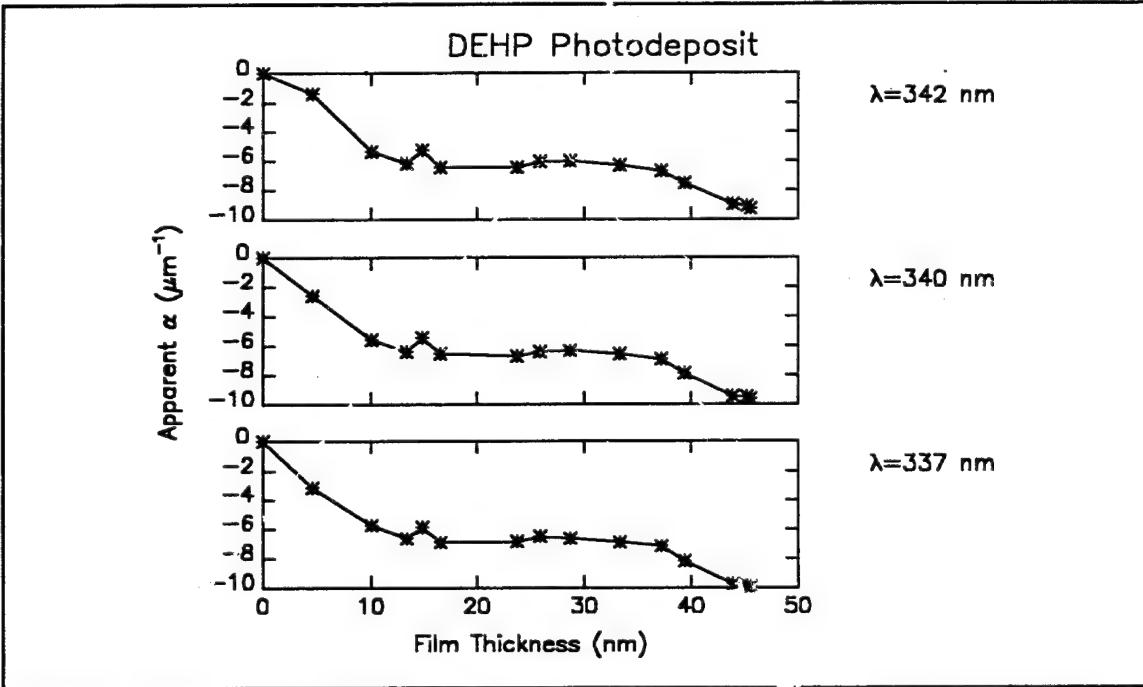


Figure C18h Computed values of α_j for photochemically deposited films of dioctyl phthalate (DEHP). (Ultraviolet wavelength range)

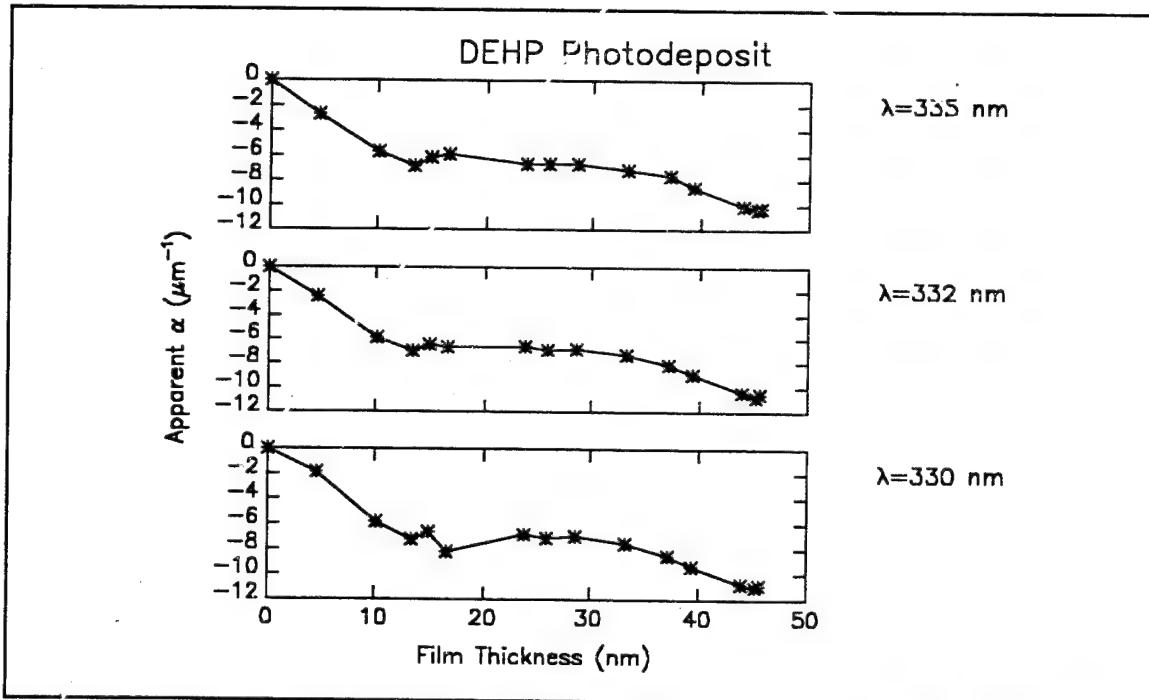


Figure C18i Computed values of α_j for photochemically deposited films of dioctyl phthalate (DEHP). (Ultraviolet wavelength range)

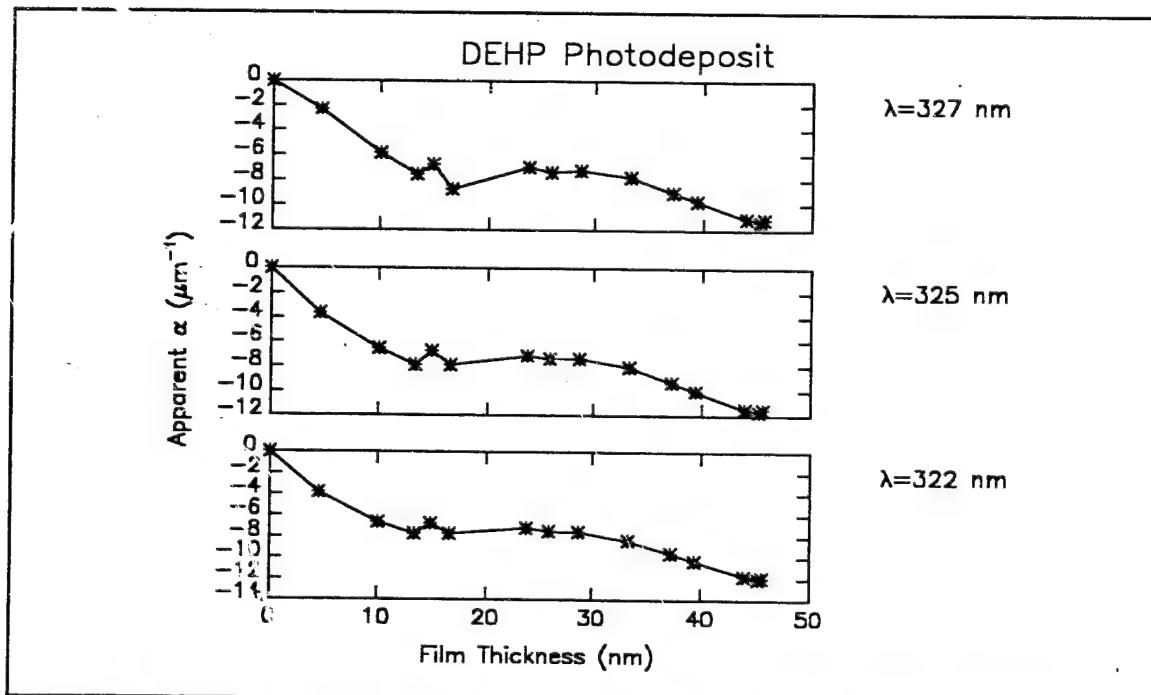


Figure C18j Computed values of α_j for photochemically deposited films of dioctyl phthalate (DEHP). (Ultraviolet wavelength range)

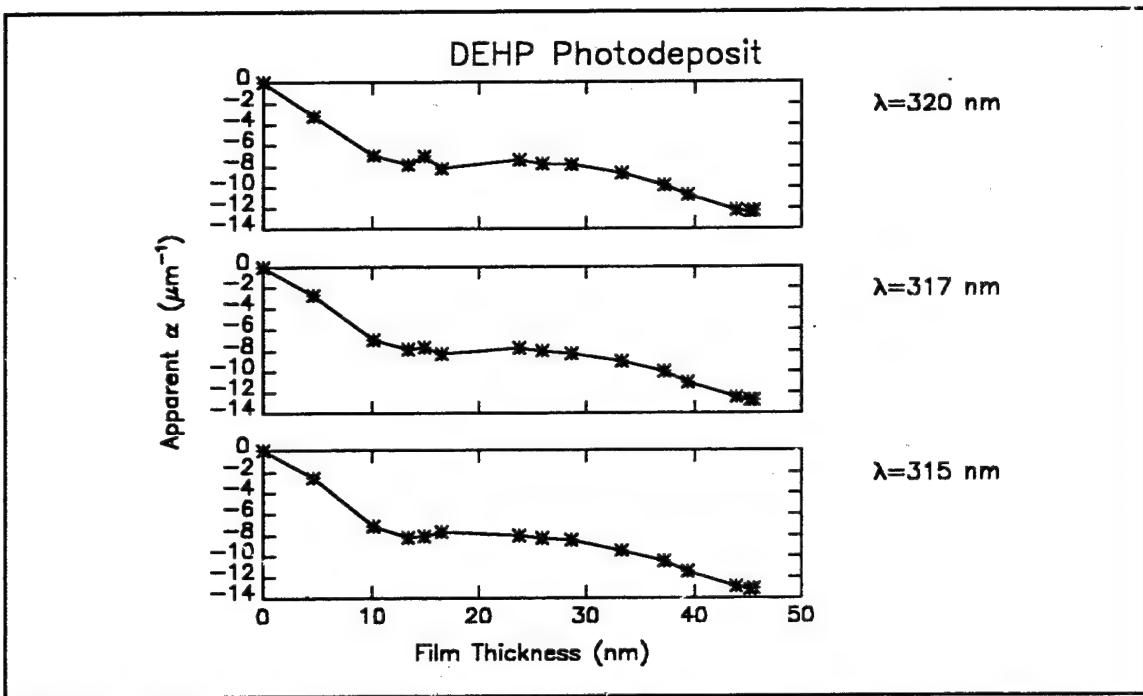


Figure C18k Computed values of α_j for photochemically deposited films of dioctyl phthalate (DEHP). (Ultraviolet wavelength range)

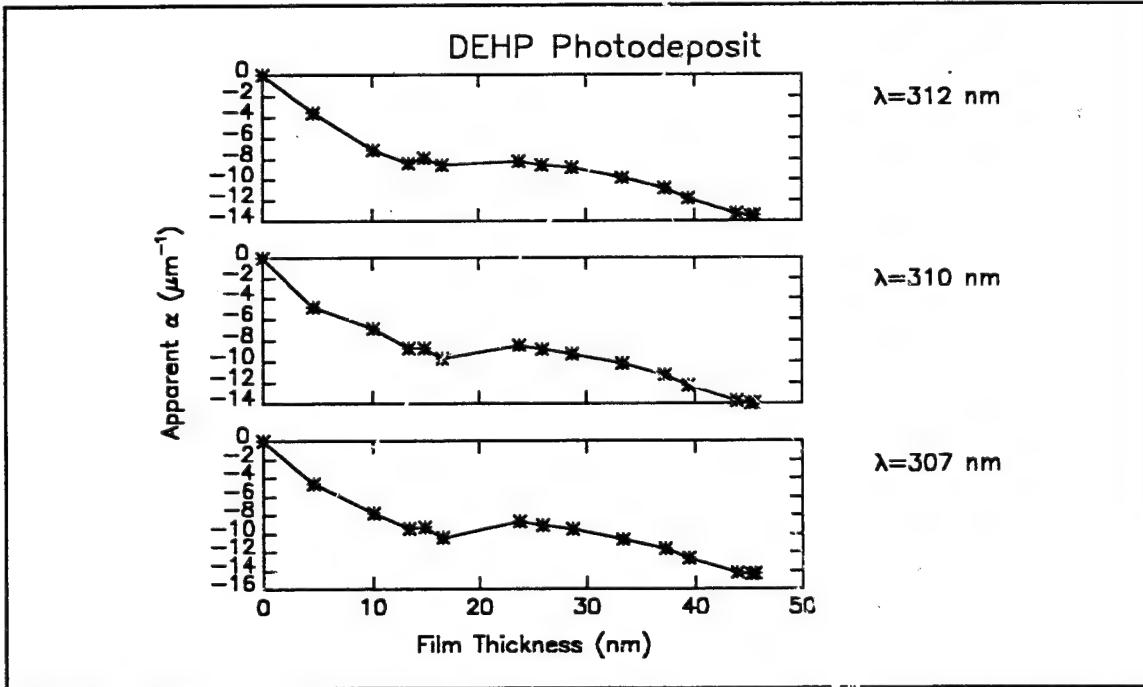


Figure C18l Computed values of α_j for photochemically deposited films of dioctyl phthalate (DEHP). (Ultraviolet wavelength range)

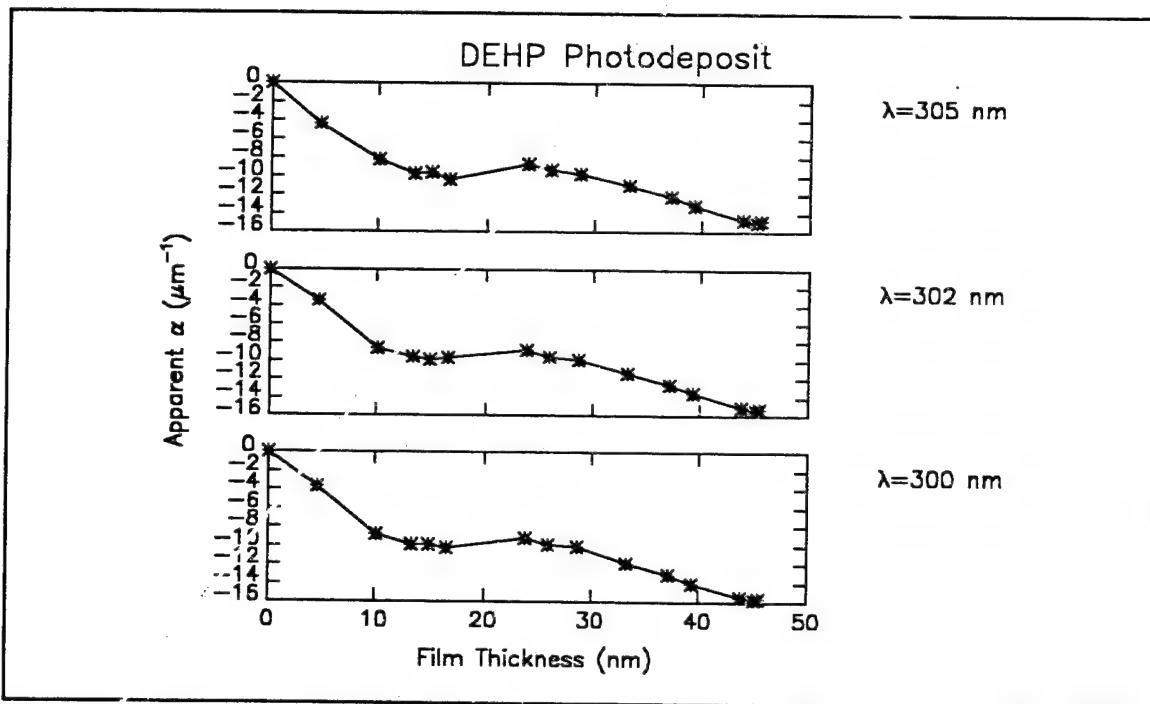


Figure C18m Computed values of α_i for photochemically deposited films of dioctyl phthalate (DEHP). (Ultraviolet wavelength range)

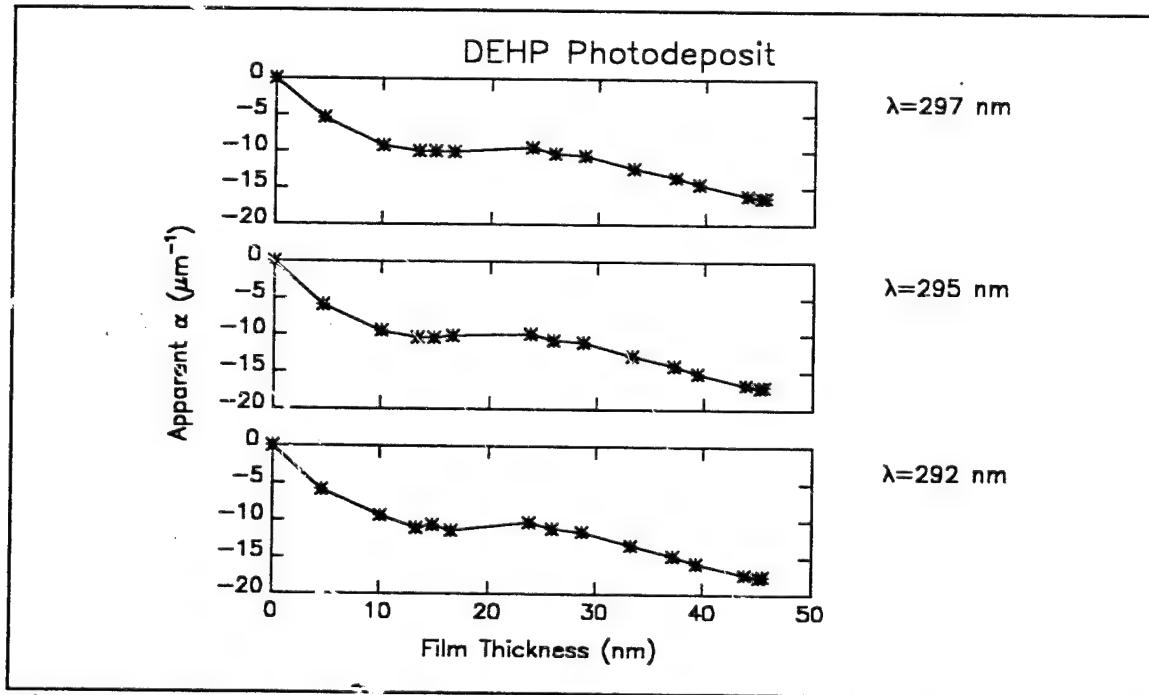


Figure C18n Computed values of α_i for photochemically deposited films of dioctyl phthalate (DEHP). (Ultraviolet wavelength range)

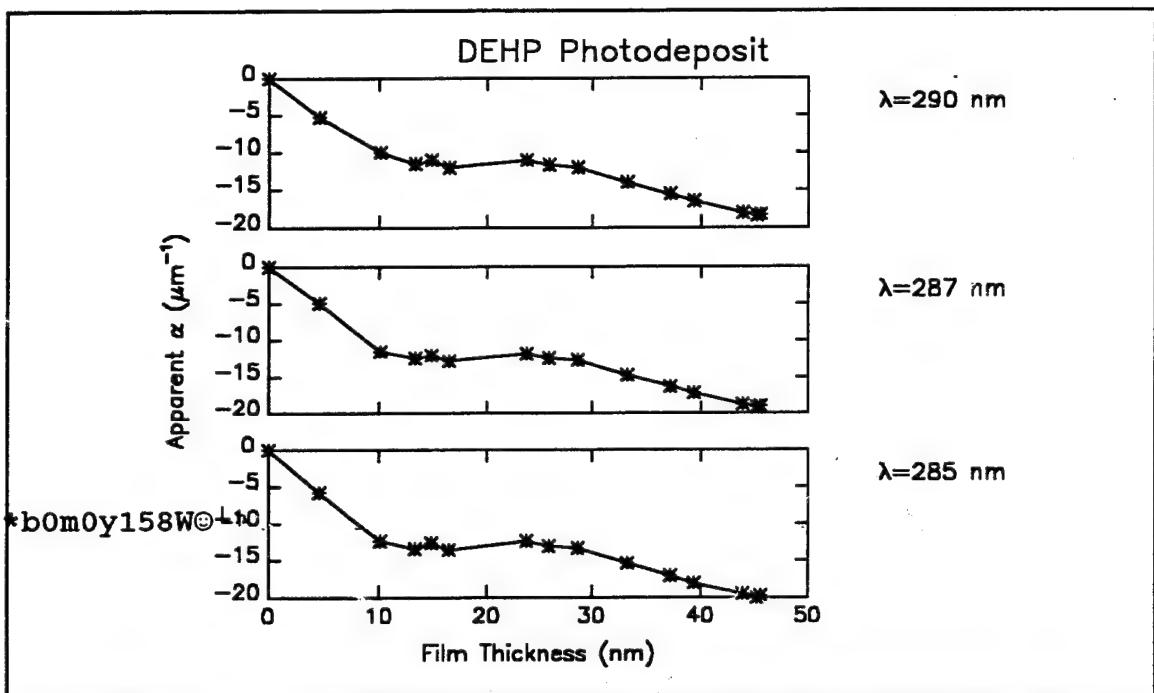


Figure C18o Computed values of α_j for photochemically deposited films of dioctyl phthalate (DEHP). (Ultraviolet wavelength range)

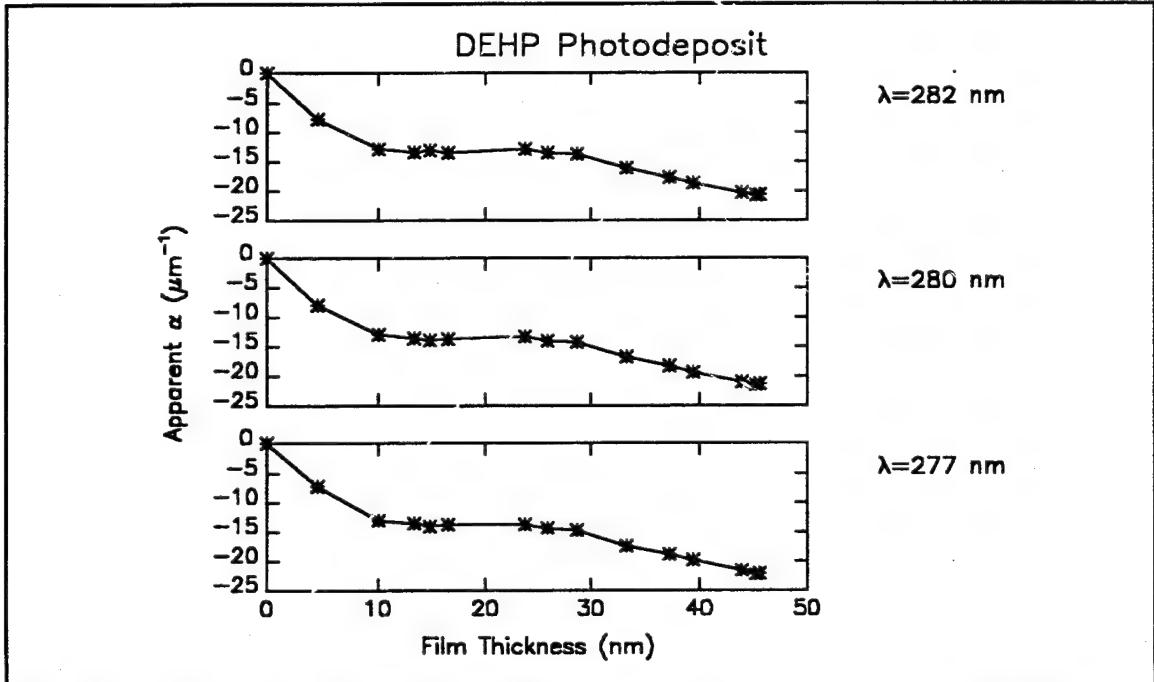


Figure C18p Computed values of α_j for photochemically deposited films of dioctyl phthalate (DEHP). (Ultraviolet wavelength range)

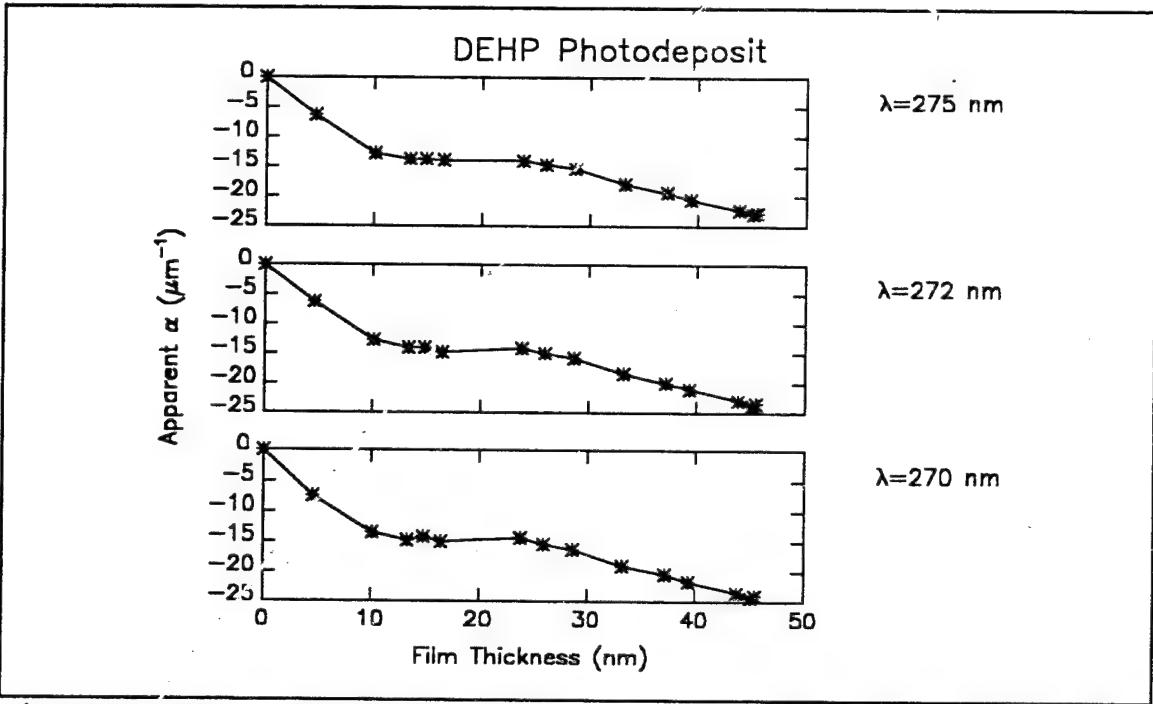


Figure C18q Computed values of α_j for photochemically deposited films of dioctyl phthalate (DEHP). (Ultraviolet wavelength range)

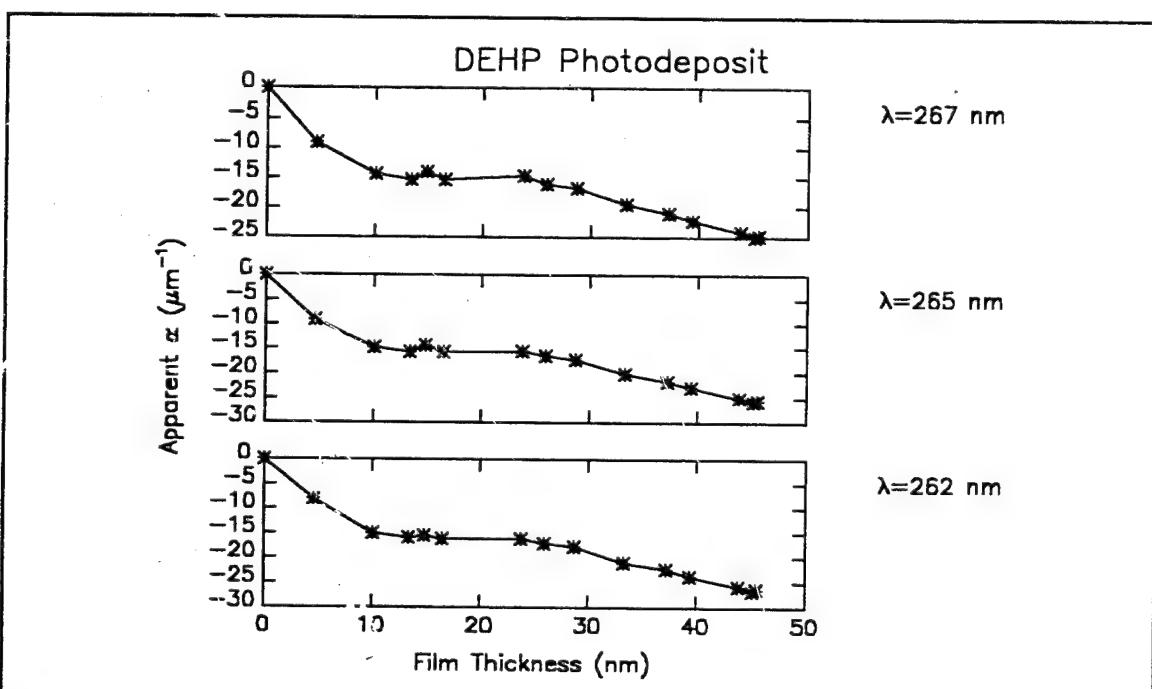


Figure C18r Computed values of α_j for photochemically deposited films of octyl phthalate (DEHP). (Ultraviolet wavelength range)

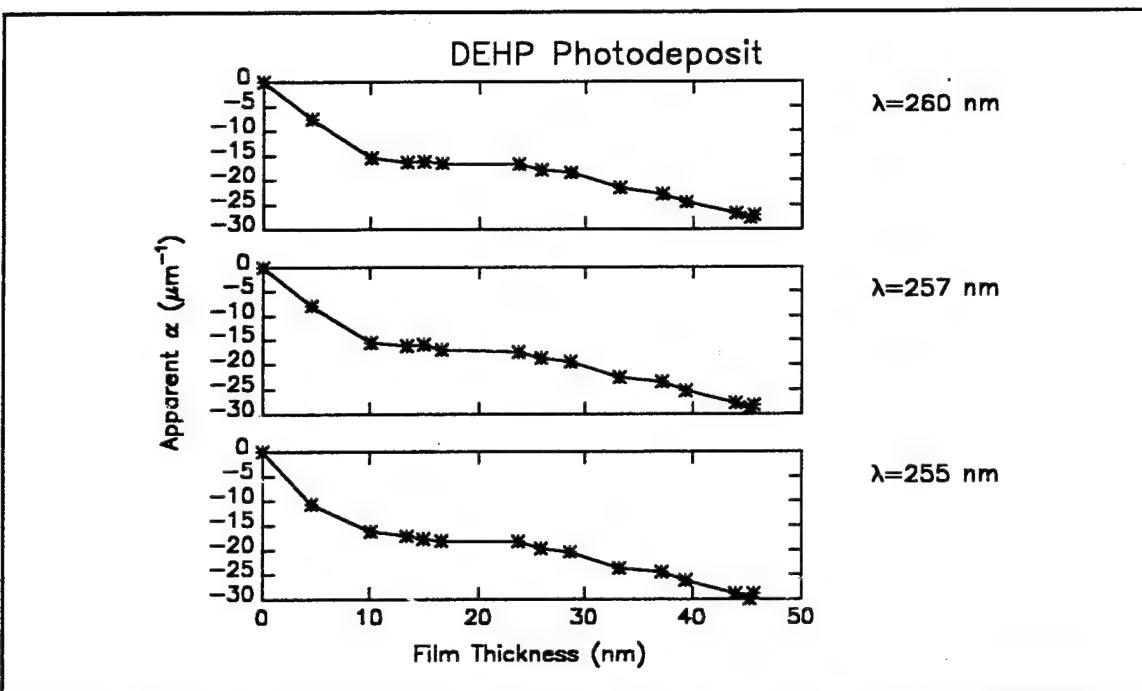


Figure C18s Computed values of α_j for photochemically deposited films of dioctyl phthalate (DEHP). (Ultraviolet wavelength range)

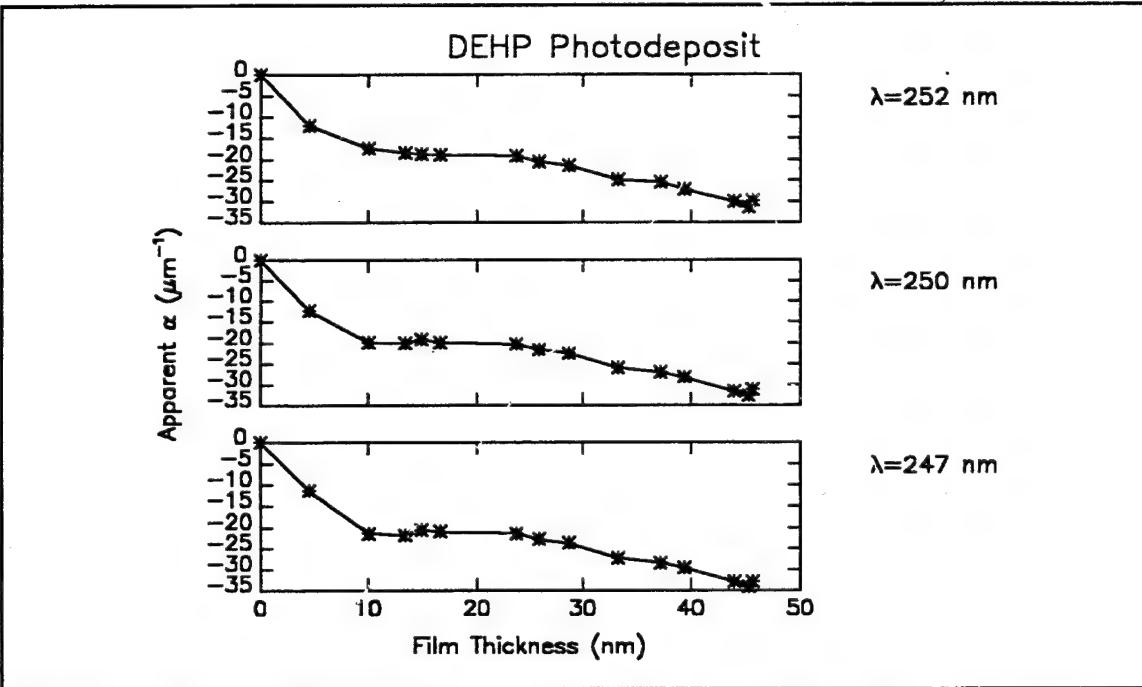


Figure C18t Computed values of α_j for photochemically deposited films of dioctyl phthalate (DEHP). (Ultraviolet wavelength range)

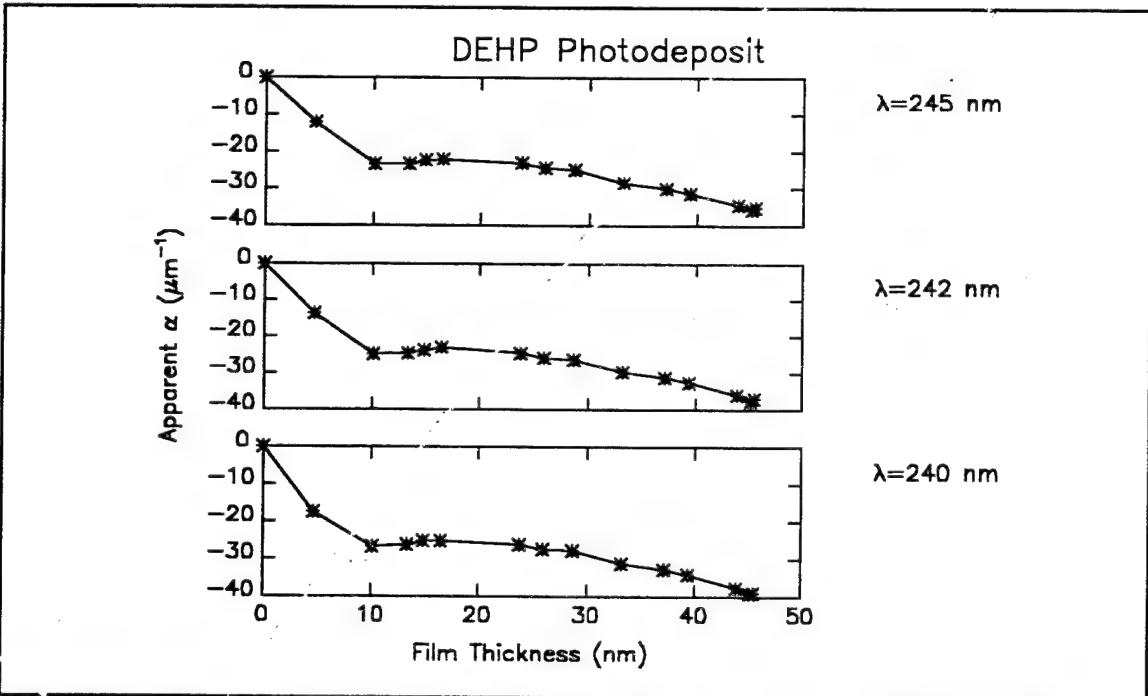


Figure C18u Computed values of α_j for photochemically deposited films of dioctyl phthalate (DEHP). (Ultraviolet wavelength range)

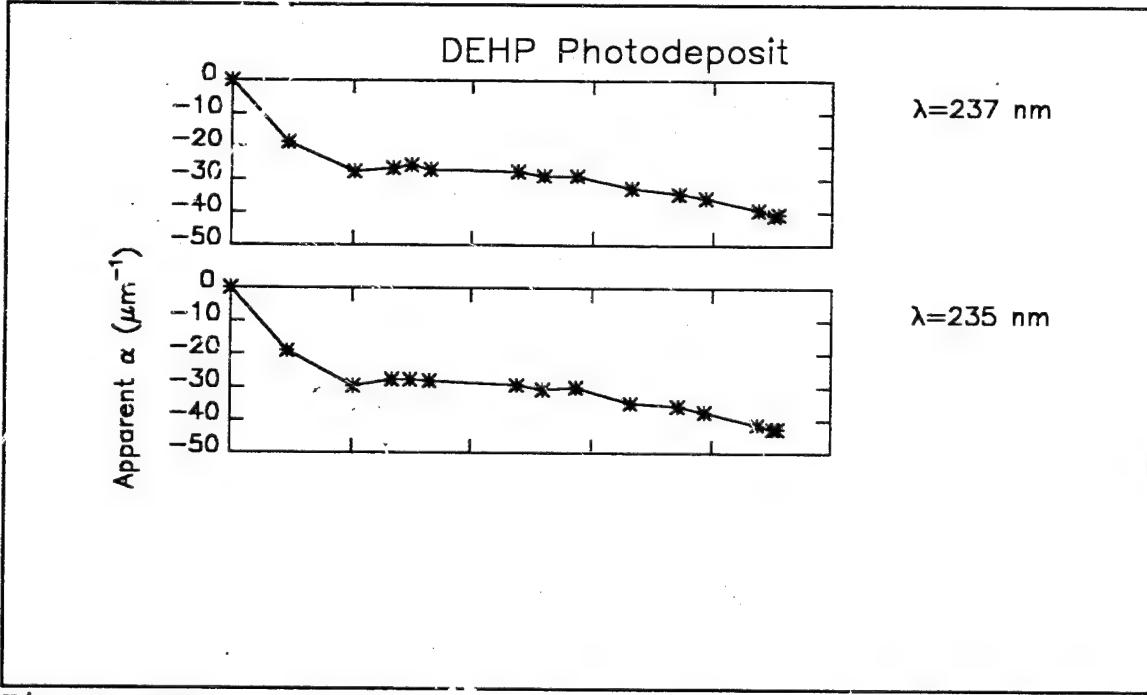


Figure C18v Computed values of α_j for photochemically deposited films of dioctyl phthalate (DEHP). (Ultraviolet wavelength range)

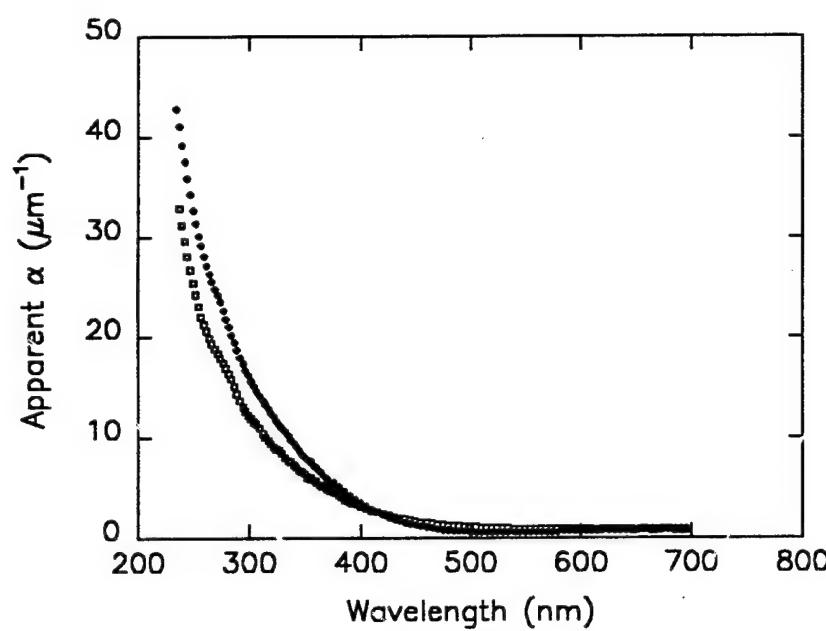


Figure C19. Apparent absorption coefficient (μm^{-1}) of the DEHP photodeposited film, linear plot. Squares, averaging for thick films. Diamonds, Beer's law fit of the entire data set.

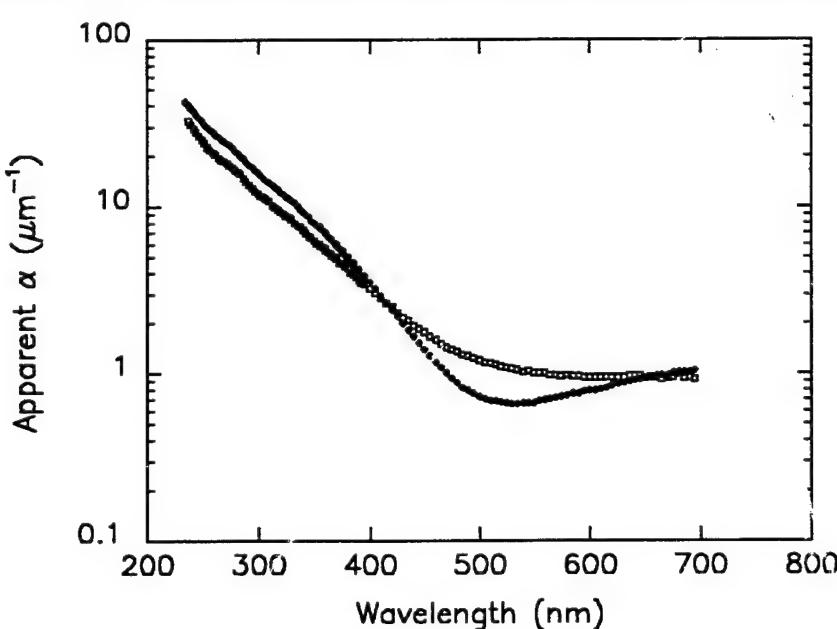


Figure C20. Apparent absorption coefficient (μm^{-1}) of the DEHP photodeposited film, log plot. Squares, averaging for thick films. Diamonds, Beer's law fit of the entire data set.

Appendix D—Squalene

SPECTRA AND FIT RESULTS FOR THE SQUALENE PHOTODEPOSIT

This appendix archives the deposition data and transmission spectra measured during a roughly 30 day continuous experiment in which a contaminant film was photochemically deposited from the precursor material squalene. This model contaminant, an unsaturated hydrocarbon, serves as an analog for the materials that outgas from a variety of materials.

1.0 DEPOSITION DATA AND TRANSMISSION SPECTRA

Figure D1 shows the TQCM data measured during the photochemical deposition of squalene. The film grew at a rate of about 1 Hz/hour (0.04 nm/hour) throughout most of the 800 hour experiment.

The nominal film thickness was calculated assuming a density of 1 g/cm² and a TQCM calibration coefficient of 4.43 ng/cm²/Hz. Toward the end of the deposition, the QCM output became very noisy. There were large, rapid, anomalous shifts in the output that were not attributable to actual mass changes. It was possible, by close examination of the data, to extract film reliable apparent film thicknesses.

Table D1 shows the nominal thicknesses at which ultraviolet (395-225 nm) transmission spectra were measured. Table D2 shows the nominal thicknesses at which visible transmission spectra were measured.

Table D1 Nominal film thicknesses, nm, at which ultraviolet wavelength range spectra were measured.

0.01	0.01	2.4	3.5	3.4	8.8	9.8	11.6	18.4	20.1
20.8	23.1	28.1	31.4	32.4	36.5	37.4	39.0	40.9	
46.1	46.1								

The transmission spectra are plotted in Figures D2 through D10. Where multiple measurements were made at a single thickness, the data are overplotted. During the early preparations for the deposition, the adsorption-desorption behavior of the squalene was measured. This resulted in some contamination of the witness

sample that did not seem to be reversible. (See Figure D2). Therefore, to perform the spectral analyses described below, two clean spectra of the Corning 7940 measured during the DC704 deposition were used for the sample baseline. (See Appendix B.)

Table D2 Nominal film thicknesses, nm, at which visible wavelength range spectra were measured.

0.01	0.01	1.9	1.9	2.4	3.5	3.4	8.8	9.8	9.8	11.6
11.6	18.4	20.1	20.1	20.8	23.1	28.1	31.4	32.4		
36.5	37.4	39.0	40.9	46.1	46.1					

2.0 BEER'S LAW FITS

The transmission spectra were fit to the Beer-Lambert absorption law,

$$\log_e(I/I_0) = -\alpha t \quad (D1)$$

where I/I_0 is the transmittance of the film, t is the film thickness, and α is the absorption coefficient of the film. The transmittance of the film was calculated as the ratio of the transmission of the deposit, on the substrate, to the transmission of the clean substrate. Note that the quantity $\log(I/I_0)$ will be called the film absorbance.

Figures D11 and D12 present the results of this analysis. The linear least-squares fits were not constrained to pass through the origin. Figure D13 shows the ratio of the fitted intercept to the absolute value of the largest absorbance measured. The relatively small values in this plot indicate reasonably good fits. However, the ratios are all of constant sign, indicating a systematic tendency for the fits to fail to pass through the origin.

The actual fits are shown in Figure D14 for the visible wavelengths, and D15 for the ultraviolet wavelengths.* Tables D3 and D4 present the results of the visible and ultraviolet fits, respectively. The data appear concave upward, and shifted from intercepting the origin. This may indicate a small error in the thickness scale or in the baseline correction. Even so the fits are remarkably satisfying.

* Note that the plots show the absorption coefficient as a negative number, which is opposite to the sign convention shown in equation D1.

3.0 CONSTRAINED FITS

Because data for some of the materials studied show curvature of the absorbance vs. thickness plots, a second approach was used to extract an apparent absorption coefficient from the data. In this case, the "Beer's law plot" is constrained to pass through the origin, by calculating an apparent α as

$$\alpha = \langle \alpha_j \rangle = \frac{1}{j_f - j_i + 1} \sum_{j=j_i}^{j=j_f} \frac{\log_e[I(t_j)/I_0]}{t_j} \quad (D2)$$

where I/I_0 is the transmittance of the film, t_j is the film thickness for the j th measurement, and α is the absorption coefficient of the film. The transmittance of the film was calculated as the ratio of the transmission of the deposit, on the substrate, to the transmission of the clean substrate.

Figures D16 and D17 present the results of this analysis, where the average was performed for thicknesses greater than 30 nm in the visible and greater than 40 nm in the ultraviolet. The constrained data, α_j , are shown in Figure D18 for the visible wavelengths, and D19 for the ultraviolet wavelengths. Tables D5 and D6 present the results of the visible and ultraviolet fits, respectively.

4.0 COMPARISON OF THE FITS

Figures D20 and D21 provide comparisons of the apparent absorption coefficients obtained from the two fitting approaches. They are everywhere in agreement to within better than a factor of two.

Table D3. Beer's law fit results for the squalene photodeposit, visible wavelength range.

Wavelength (nm)	Apparent α (μm^{-1})	Intercept
695	0.89	0.003
690	0.91	0.004
685	0.92	0.005
680	0.93	0.006

Table D3, continued.

Wavelength (nm)	Apparent α (μm^{-1})	Intercept
675	0.95	0.006
670	0.96	0.006
665	0.99	0.006
660	1.01	0.006
655	1.04	0.005
650	1.06	0.006
645	1.08	0.006
640	1.10	0.007
635	1.12	0.006
630	1.16	0.006
625	1.19	0.007
620	1.22	0.007
615	1.24	0.007
610	1.28	0.008
605	1.31	0.008
600	1.35	0.008
595	1.38	0.009
590	1.42	0.009
585	1.46	0.010
580	1.49	0.009
575	1.53	0.010
570	1.59	0.010
565	1.63	0.011
560	1.68	0.011
555	1.73	0.011
550	1.79	0.012
545	1.86	0.011

Table D3, continued.

Wavelength (nm)	Apparent α (μm^{-1})	Intercept
540	1.91	0.012
535	1.98	0.012
530	2.05	0.012
525	2.12	0.013
520	2.20	0.013
515	2.27	0.013
510	2.36	0.014
505	2.45	0.014
500	2.54	0.015
495	2.63	0.015
490	2.73	0.016
485	2.84	0.016
480	2.95	0.017
475	3.07	0.017
470	3.20	0.018
465	3.33	0.019
460	3.46	0.020
455	3.59	0.021
450	3.73	0.022
445	3.89	0.023
440	4.04	0.024
435	4.21	0.026
430	4.37	0.026
425	4.55	0.028
420	4.74	0.030
415	4.93	0.031
410	5.12	0.034

Table D3, continued.

Wavelength (nm)	Apparent α (μm^{-1})	Intercept
405	5.32	0.035
400	5.52	0.037
395	5.74	0.040
390	5.96	0.042
385	6.20	0.044
380	6.44	0.047
375	6.68	0.051
370	6.95	0.054
365	7.21	0.058
360	7.46	0.061
355	7.76	0.065

Table D4. Beer's law fit results for the squalene photodeposit, ultraviolet wavelength range.

Wavelength	Apparent α (μm^{-1})	Intercept (see plots)
395.0	6.26	0.039
392.5	6.36	0.040
390.0	6.45	0.042
387.5	6.53	0.043
385.0	6.67	0.043
382.5	6.77	0.045
380.0	6.90	0.044
377.5	7.05	0.045
375.0	7.19	0.048
372.5	7.37	0.049
370.0	7.51	0.049

Table D4, continued

Wavelength	Apparent α (μm^{-1})	Intercept (see plots)
367.5	7.67	0.051
365.0	7.81	0.052
362.5	7.97	0.054
360.0	8.13	0.055
357.5	8.30	0.056
355.0	8.45	0.058
352.5	8.61	0.060
350.0	8.77	0.062
347.5	8.90	0.064
345.0	9.12	0.063
342.5	9.32	0.065
340.0	9.50	0.065
337.5	9.64	0.068
335.0	9.82	0.069
332.5	9.96	0.072
330.0	10.11	0.074
327.5	10.27	0.076
325.0	10.45	0.078
322.5	10.61	0.080
320.0	10.78	0.081
317.5	10.96	0.083
315.0	11.14	0.085
312.5	11.31	0.088
310.0	11.51	0.090
307.5	11.76	0.091
305.0	12.03	0.093
302.5	12.29	0.095

Table D4, continued

Wavelength	Apparent α (μm^{-1})	Intercept (see plots)
300.0	12.50	0.099
297.5	12.78	0.099
295.0	13.01	0.102
292.5	13.25	0.104
290.0	13.52	0.107
287.5	13.82	0.110
285.0	14.13	0.112
282.5	14.39	0.116
280.0	14.68	0.118
277.5	14.98	0.120
275.0	15.24	0.123
272.5	15.50	0.127
270.0	15.76	0.129
267.5	16.00	0.132
265.0	16.27	0.134
262.5	16.50	0.137
260.0	16.73	0.140
257.5	16.98	0.144
255.0	17.20	0.148
252.5	17.46	0.150
250.0	17.73	0.151
247.5	17.93	0.154
245.0	18.15	0.157
242.5	18.40	0.159
240.0	18.74	0.159
237.5	19.06	0.159
235.0	19.35	0.161

Table D5. Apparent absorption coefficients from the constrained fits, visible wavelengths.

Wavelength (nm)	Apparent α (μm^{-1})
695	0.97
690	1.02
685	1.05
680	1.10
675	1.12
670	1.14
665	1.15
660	1.17
655	1.20
650	1.22
645	1.25
640	1.29
635	1.31
630	1.34
625	1.38
620	1.42
615	1.45
610	1.50
605	1.53
600	1.58
595	1.63
590	1.68
585	1.73
580	1.76
575	1.81
570	1.87
565	1.93

Table D5, continued

Wavelength (nm)	Apparent α (μm^{-1})
560	1.98
555	2.04
550	2.12
545	2.18
540	2.25
535	2.32
530	2.40
525	2.47
520	2.56
515	2.64
510	2.74
505	2.84
500	2.95
495	3.05
490	3.16
485	3.28
480	3.41
475	3.54
470	3.70
465	3.84
460	4.01
455	4.16
450	4.32
445	4.51
440	4.69
435	4.89
430	5.09

Table D5, continued

Wavelength (nm)	Apparent α (μm^{-1})
425	5.30
420	5.54
415	5.75
410	6.00
405	6.25
400	6.50
395	6.78
390	7.06
385	7.35
380	7.67
375	7.99
370	8.33
365	8.69
360	9.04
355	9.41

Table D6. Apparent absorption coefficients from the constrained fits, ultraviolet wavelengths.

Wavelength (nm)	Apparent α (μm^{-1})
395.0	6.71
392.5	6.80
390.0	6.88
387.5	7.02
385.0	7.16
382.5	7.32
380.0	7.45

Table D6, continued

Wavelength (nm)	Apparent α (μm^{-1})
377.5	7.63
375.0	7.85
372.5	8.07
370.0	8.24
367.5	8.42
365.0	8.59
362.5	8.76
360.0	8.92
357.5	9.08
355.0	9.21
352.5	9.40
350.0	9.57
347.5	9.73
345.0	9.90
342.5	10.11
340.0	10.29
337.5	10.47
335.0	10.66
332.5	10.85
330.0	11.05
327.5	11.26
325.0	11.45
322.5	11.65
320.0	11.82
317.5	12.03
315.0	12.25
312.5	12.48

Table D6, continued

Wavelength (nm)	Apparent α (μm^{-1})
310.0	12.75
307.5	12.99
305.0	13.30
302.5	13.61
300.0	13.88
297.5	14.15
295.0	14.46
292.5	14.74
290.0	15.05
287.5	15.37
285.0	15.70
282.5	16.03
280.0	16.37
277.5	16.72
275.0	17.06
272.5	17.40
270.0	17.72
267.5	18.04
265.0	18.38
262.5	18.69
260.0	19.01
257.5	19.34
255.0	19.64
252.5	19.94
250.0	20.22
247.5	20.51
245.0	20.82

Table D6, continued

Wavelength (nm)	Apparent α (μm^{-1})
242.5	21.14
240.0	21.46
237.5	21.84

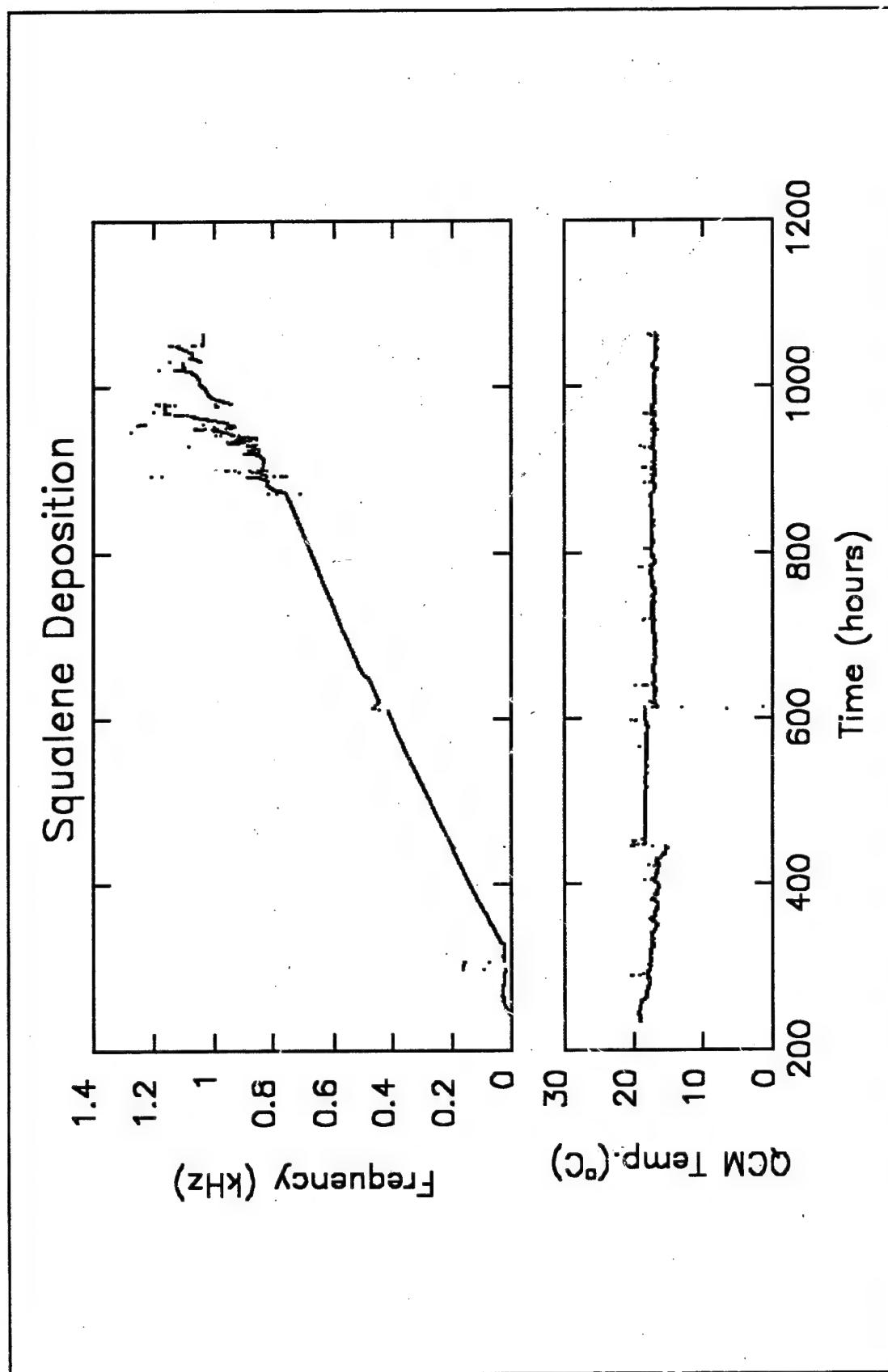


Figure D1 QCM data measured during the photochemical deposition of squalene.

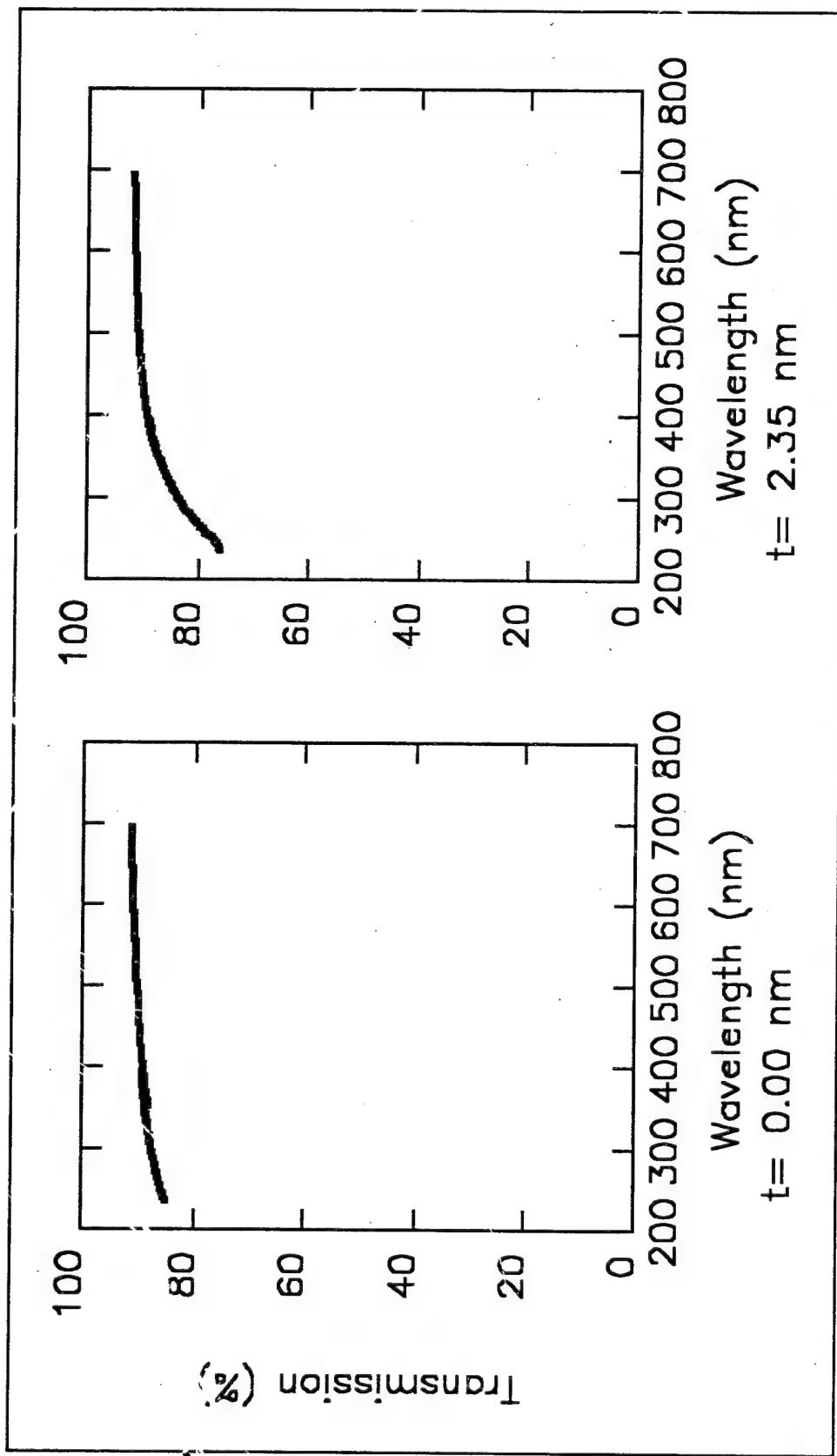


Figure D2 Transmission spectra measured during photodeposition of squalene.

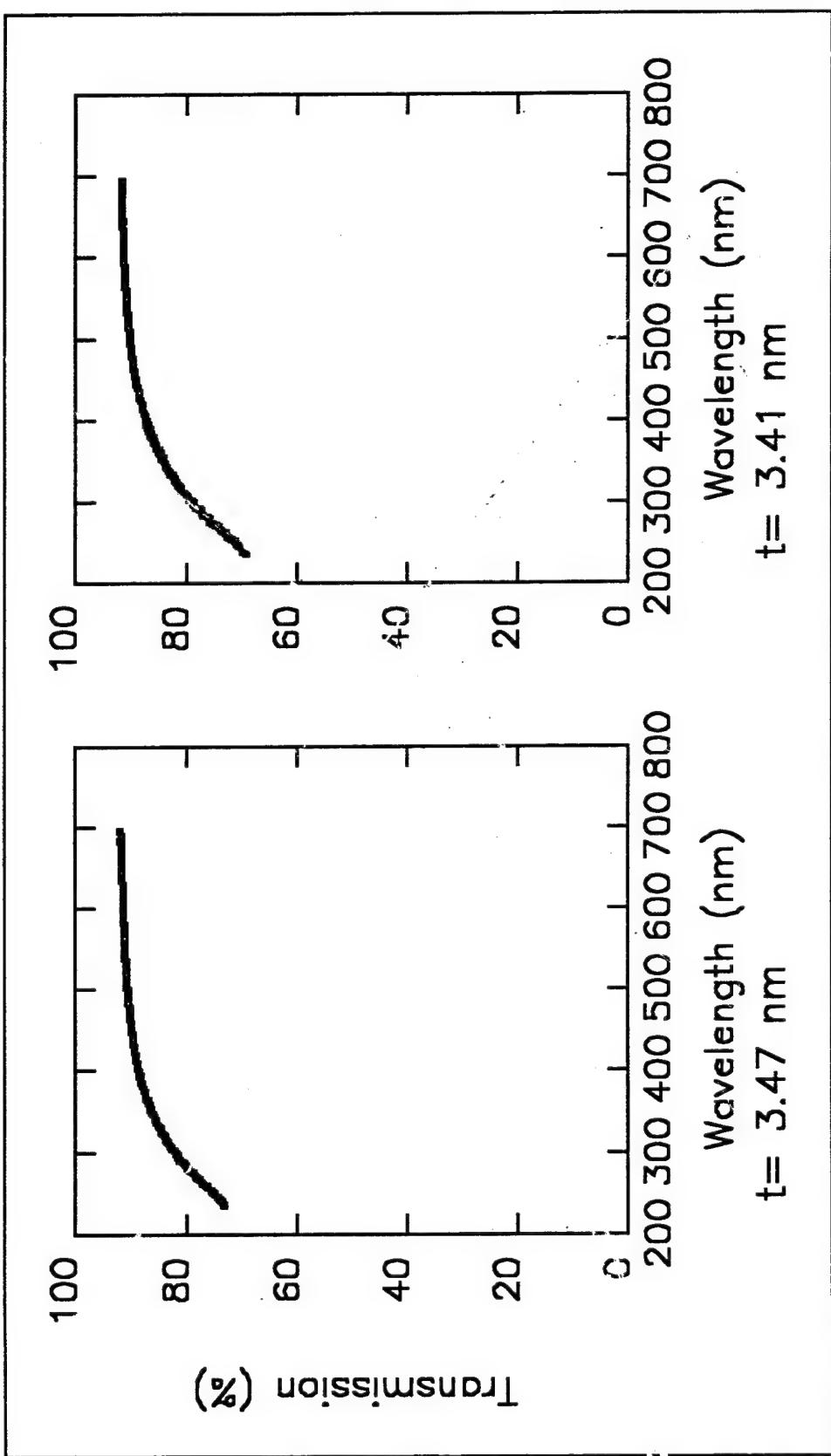


Figure D3 Transmission spectra measured during photodeposition of squalene.

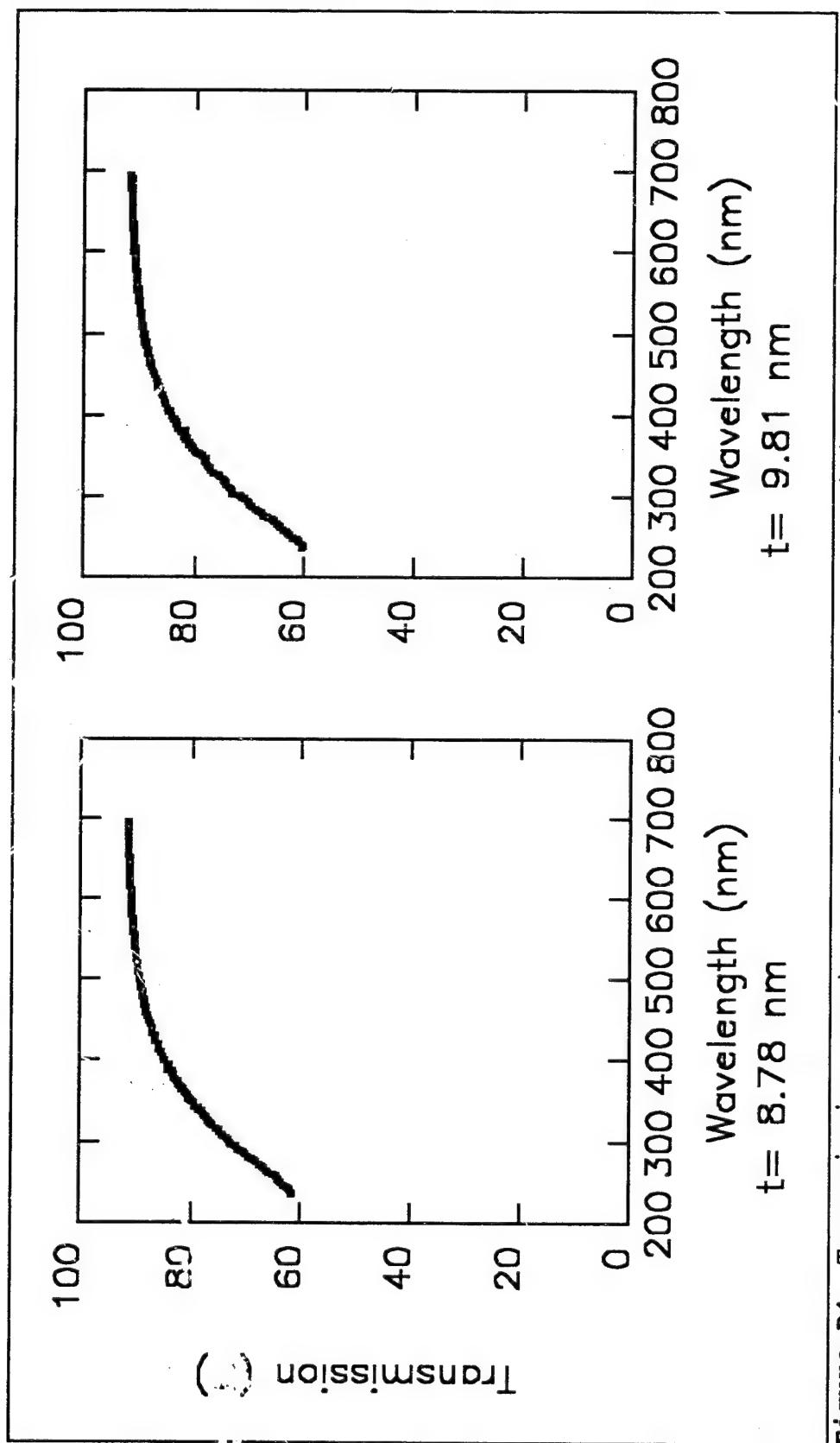


Figure D4 Transmission spectra measured during photodeposition of squalene.

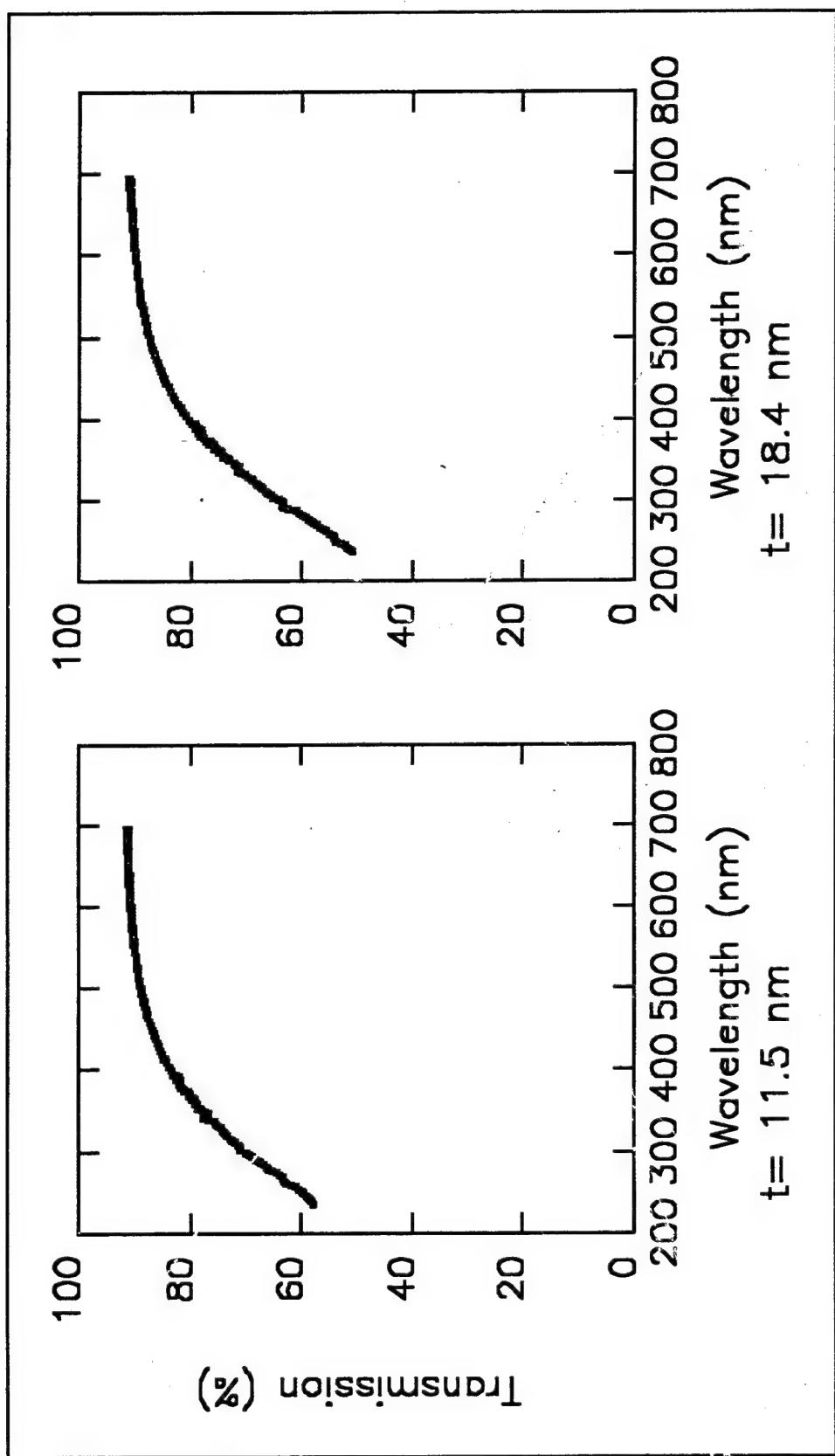


Figure D5 Transmission spectra measured during photodeposition of squalene.

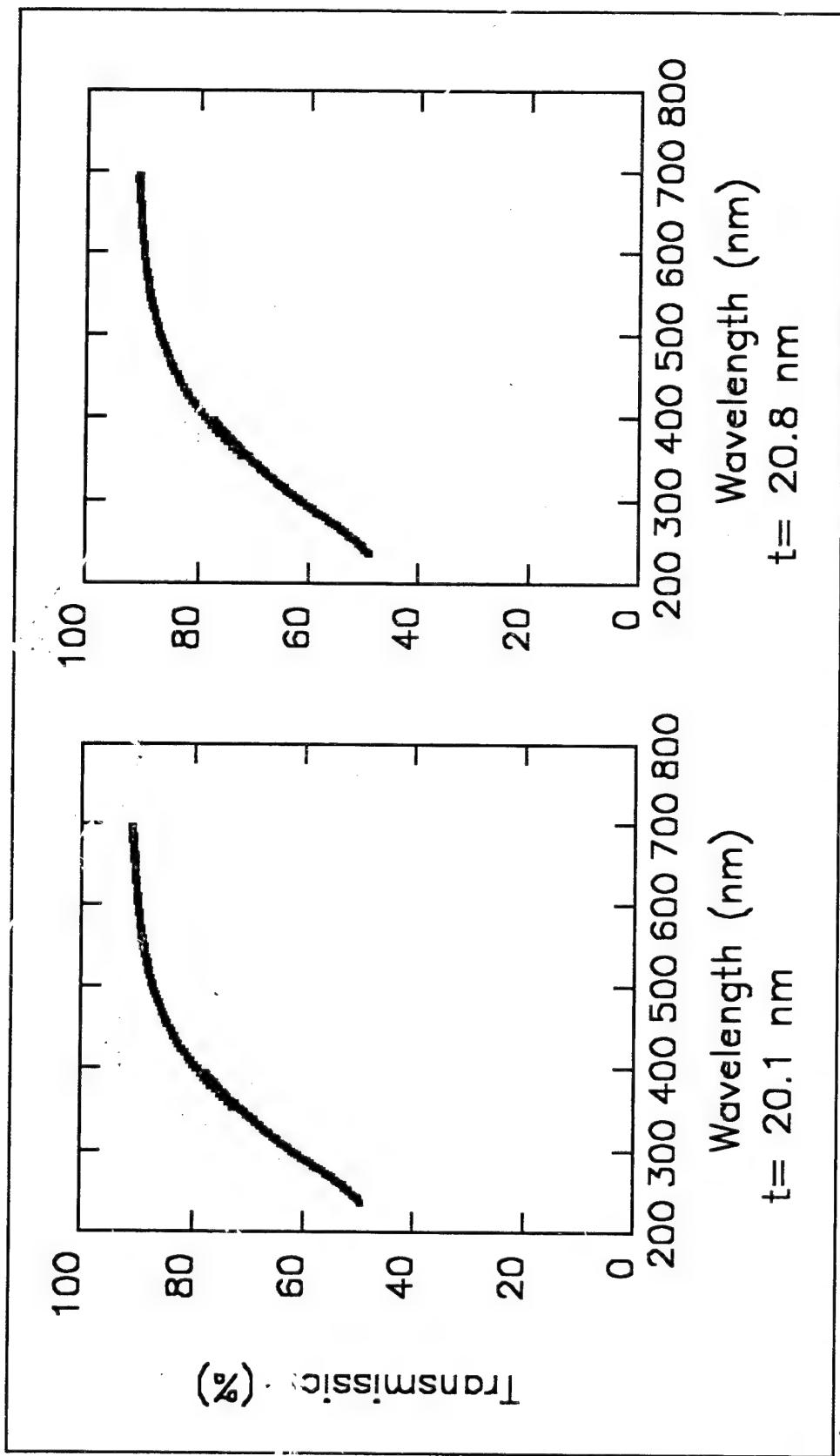


Figure D6 Transmission spectra measured during photodeposition of squalene.

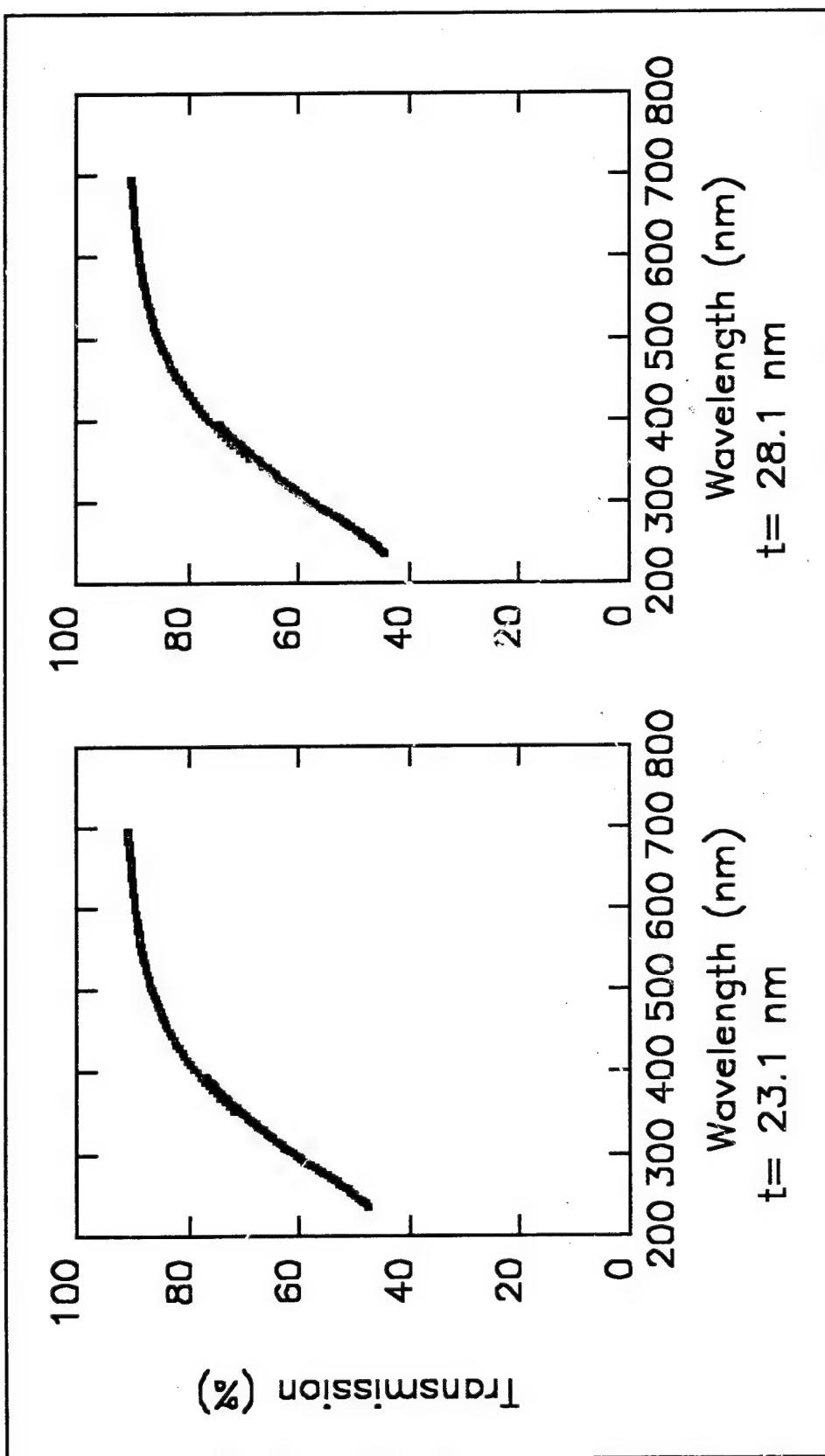
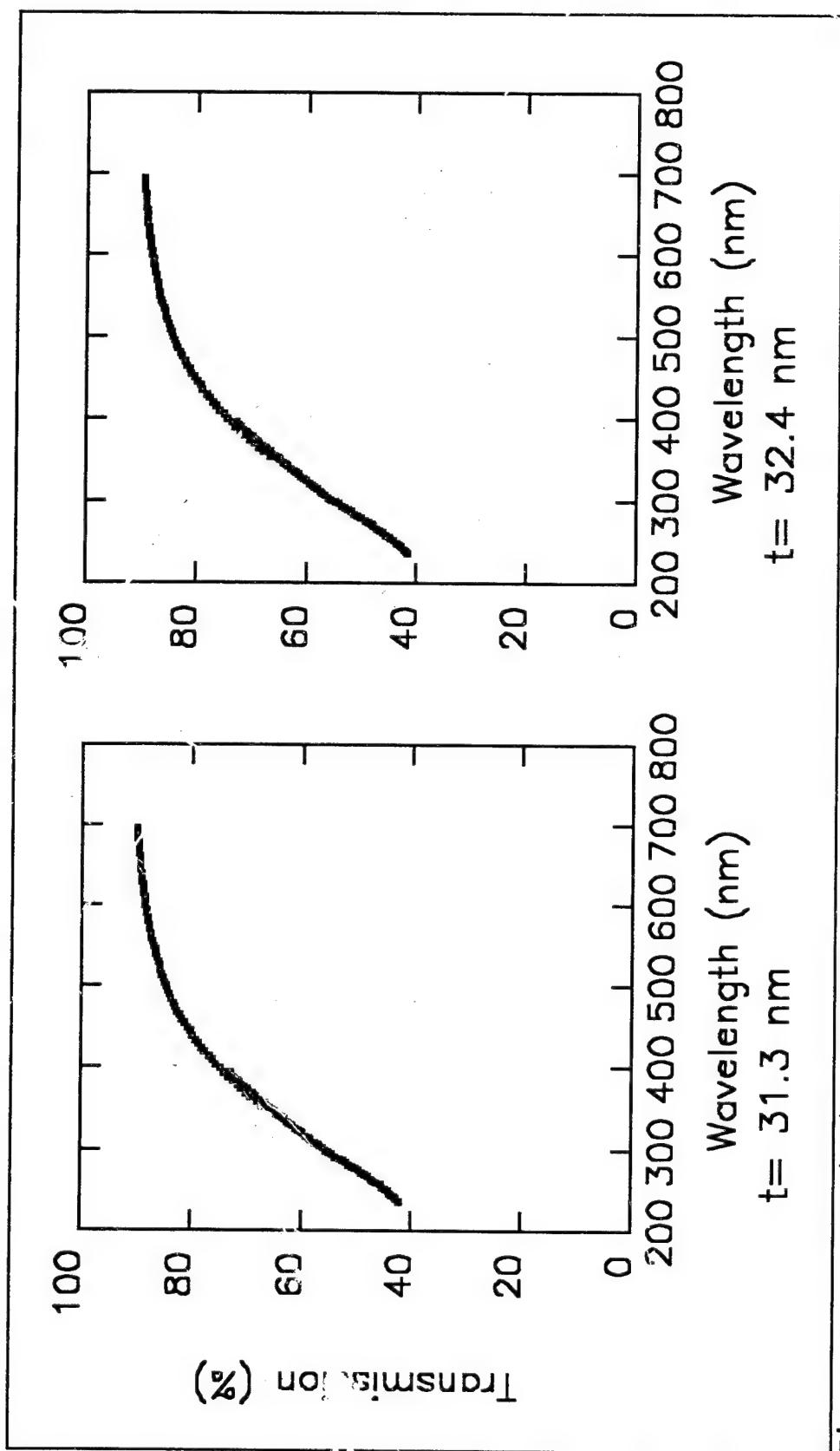


Figure D7 Transmission spectra measured during photodeposition of squalene.



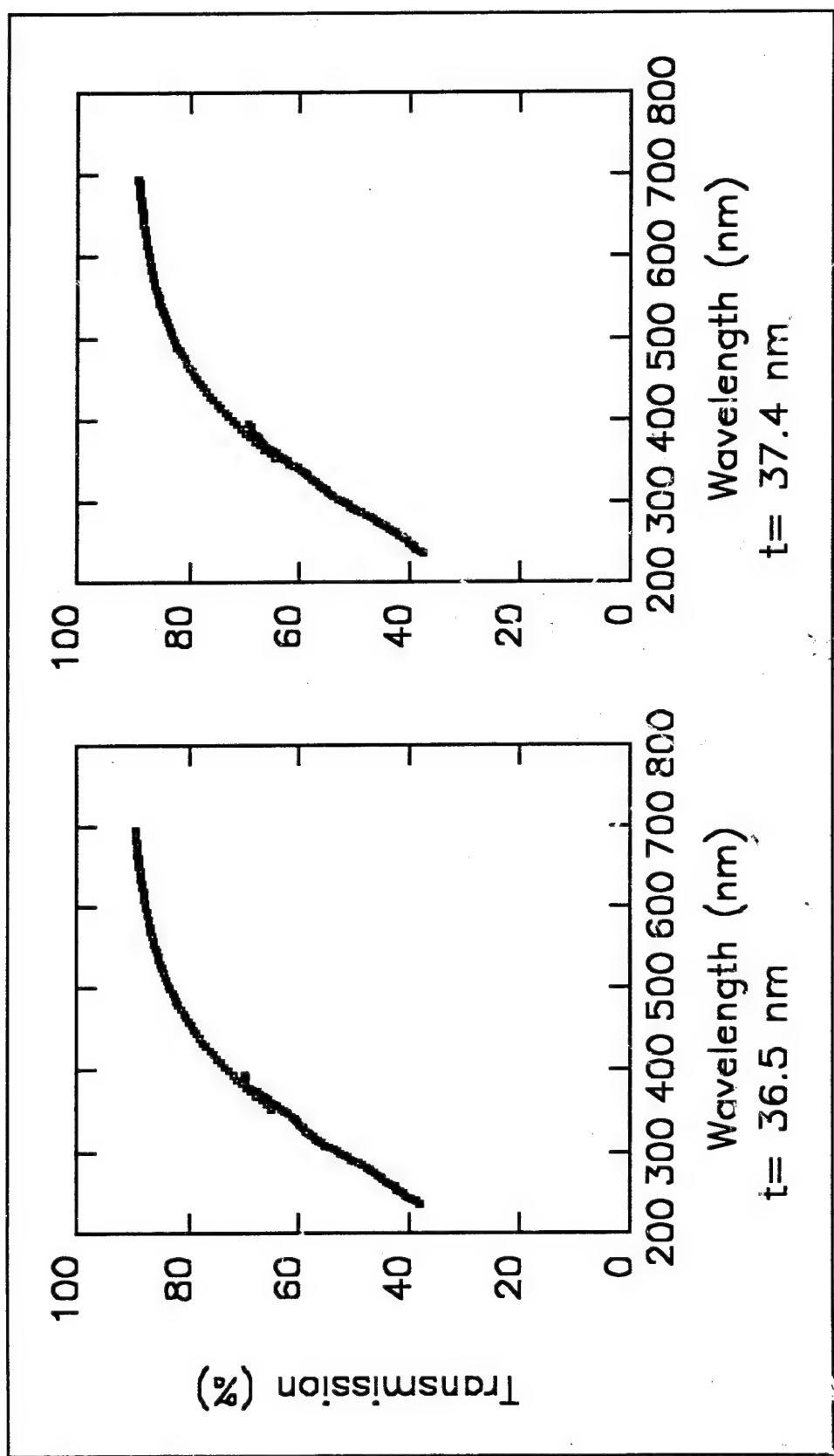
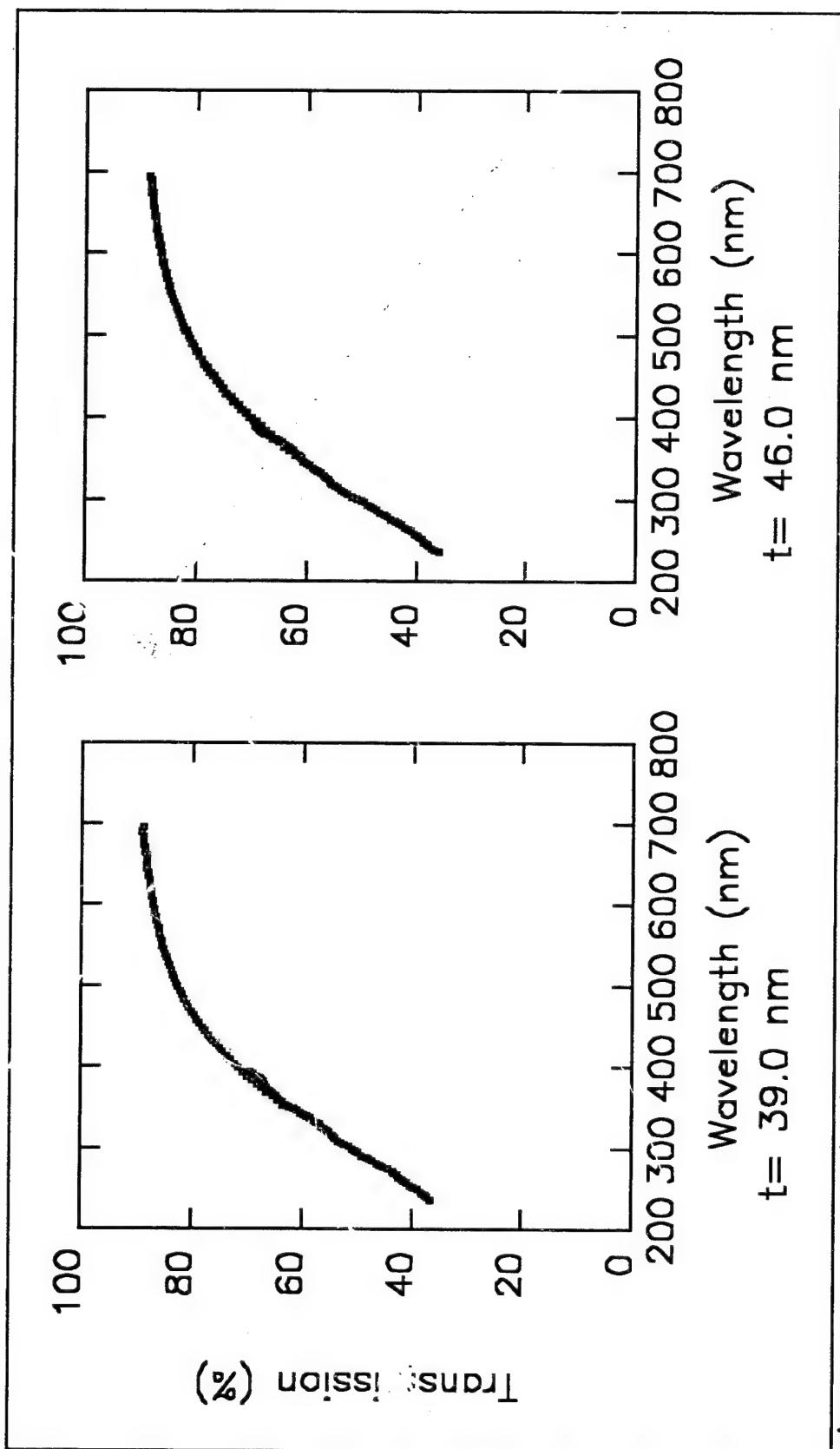


Figure D9 Transmission spectra measured during photodeposition of squalene.



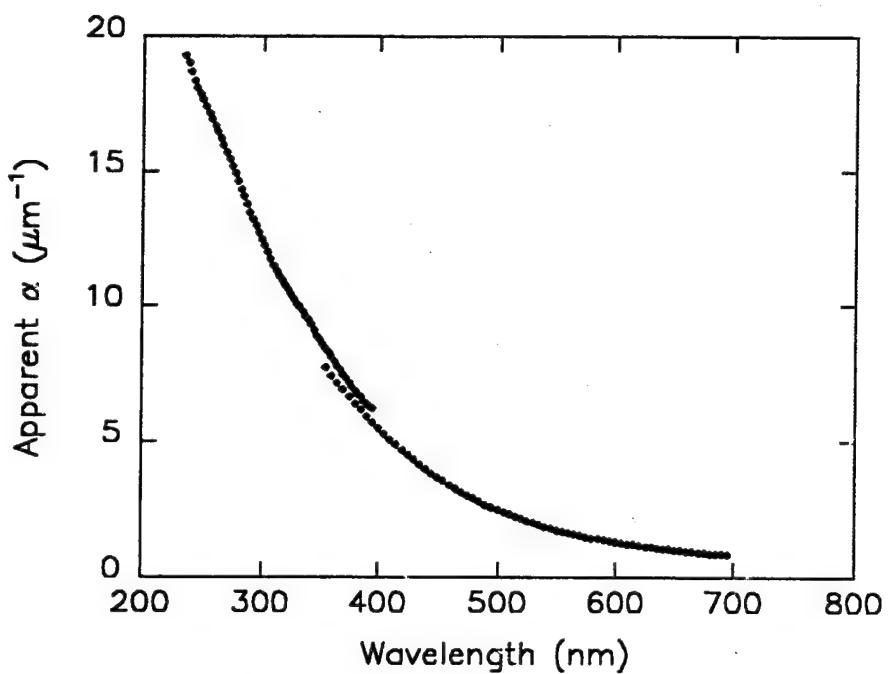


Figure D11. Apparent absorption coefficient obtained from the fits to the Beer-Lambert absorption law. Linear plot

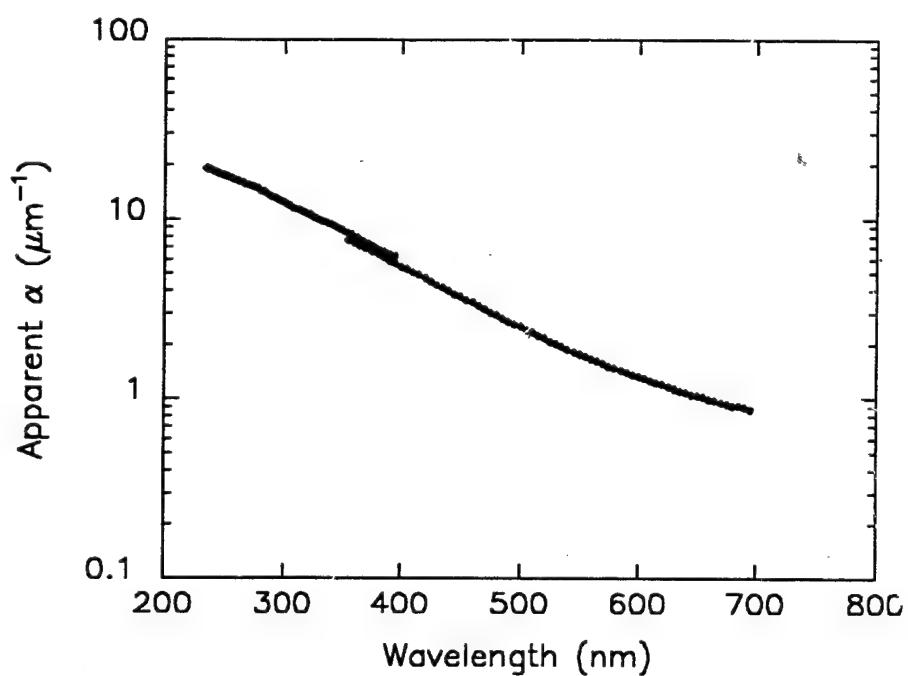


Figure D12. Apparent absorption coefficient obtained from the data fits to the Beer-Lambert absorption law. Log plot

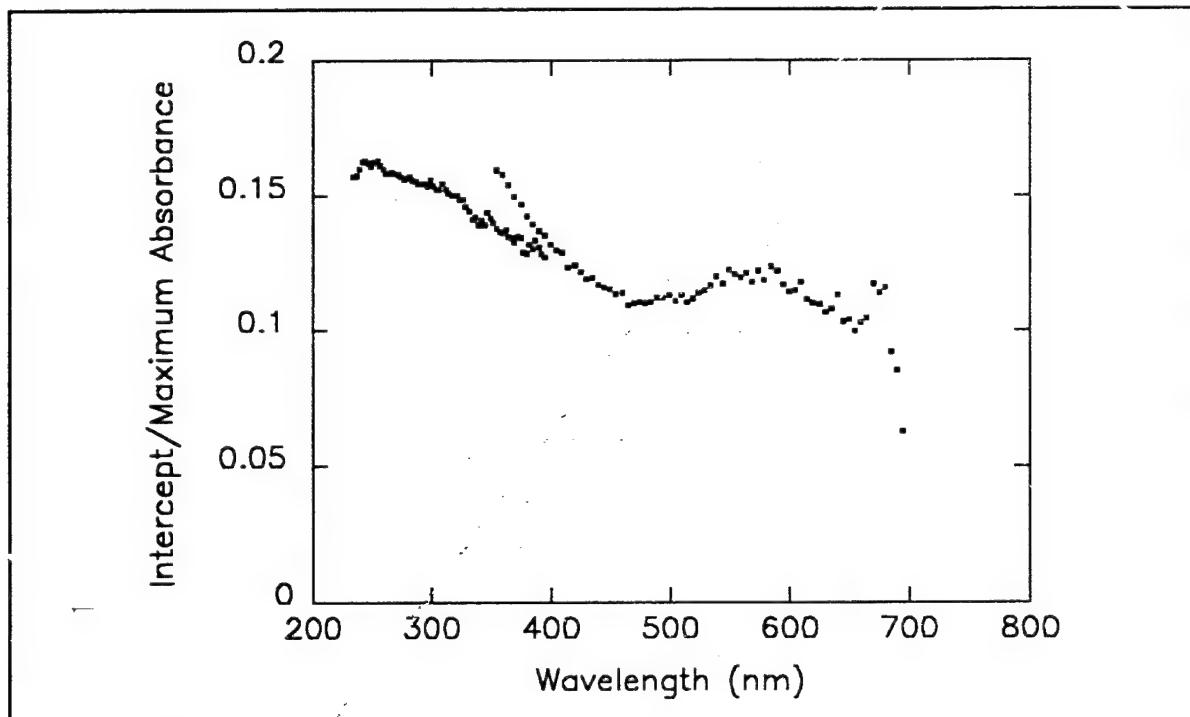


Figure D13. Plot of the ratio of the intercept of the Beer's law fit to the squalene absorption data to the maximum value of absorbance.

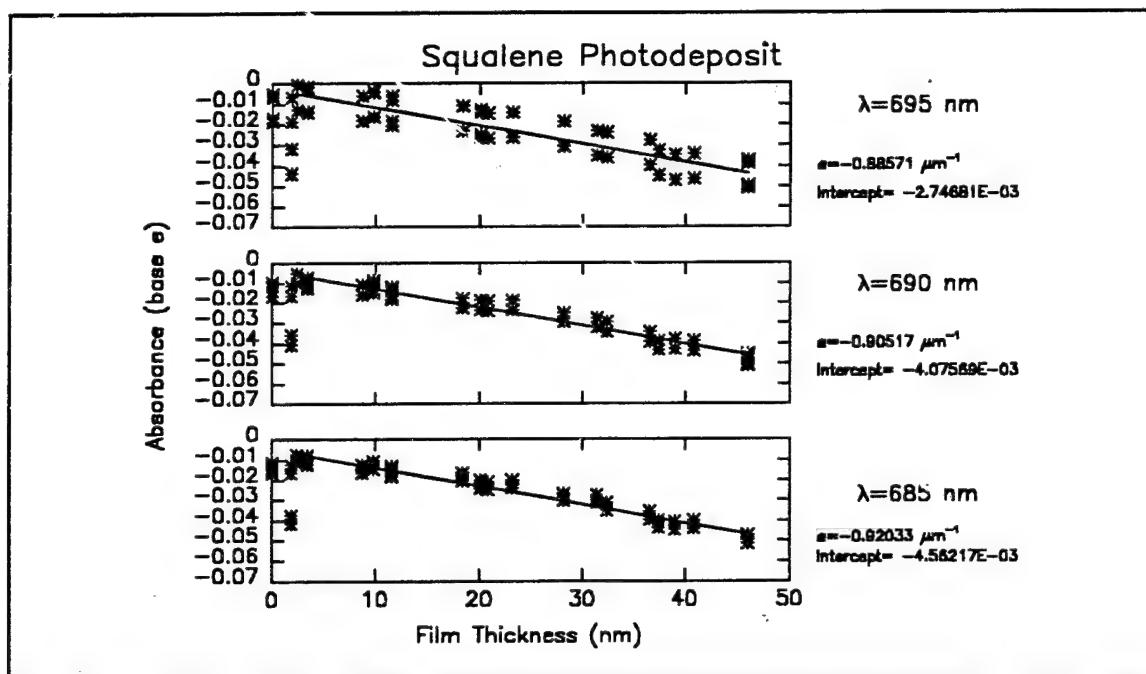


Figure D14a Fits of measured transmission spectra of the Squalene photodeposit to the Beer-Lambert absorption law. (Visible wavelength range)

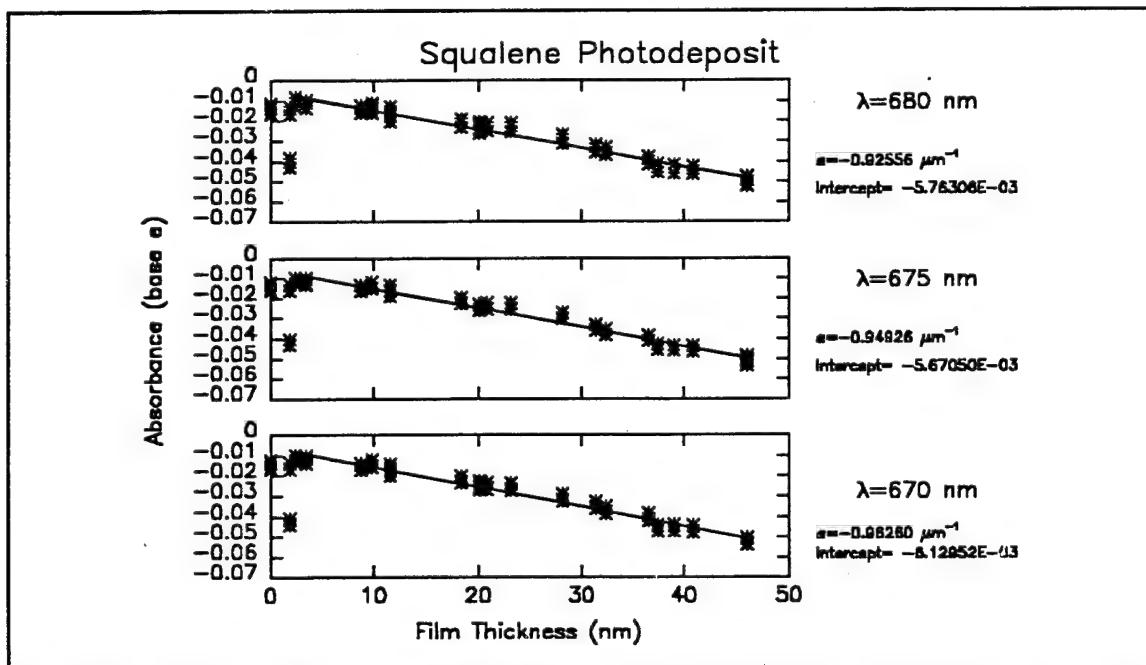


Figure D14b Fits of measured transmission spectra of the Squalene photodeposit to the Beer-Lambert absorption law. (Visible wavelength range)

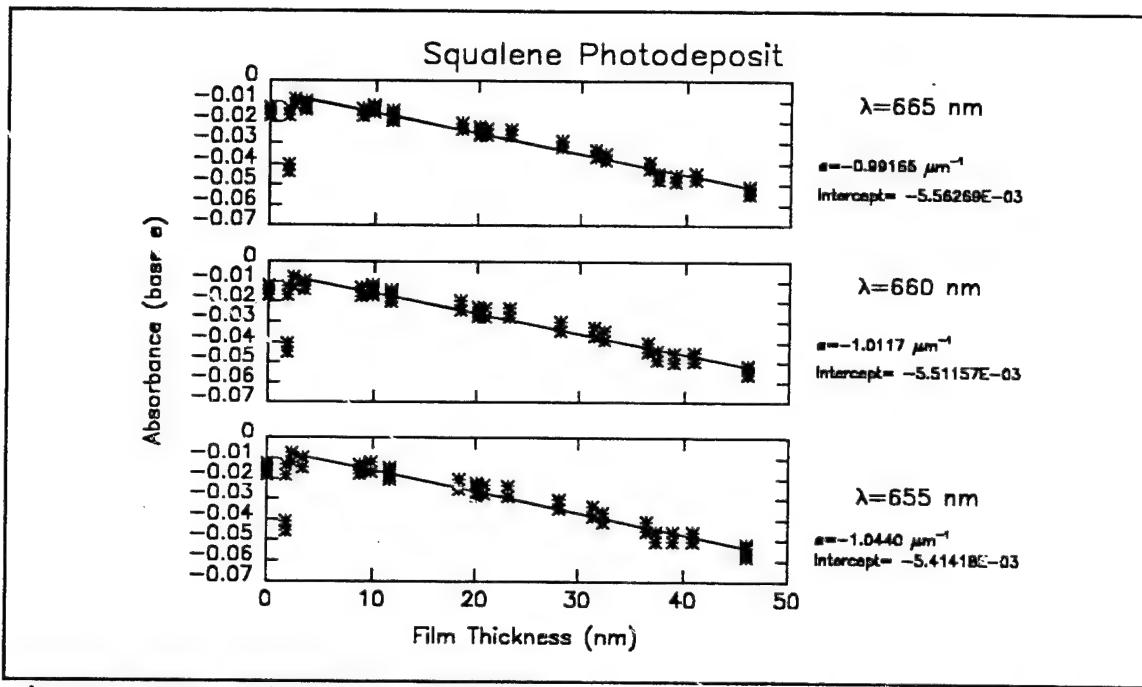


Figure D14c Fits of measured transmission spectra of the Squalene photodeposit to the Beer-Lambert absorption law. (Visible wavelength range)

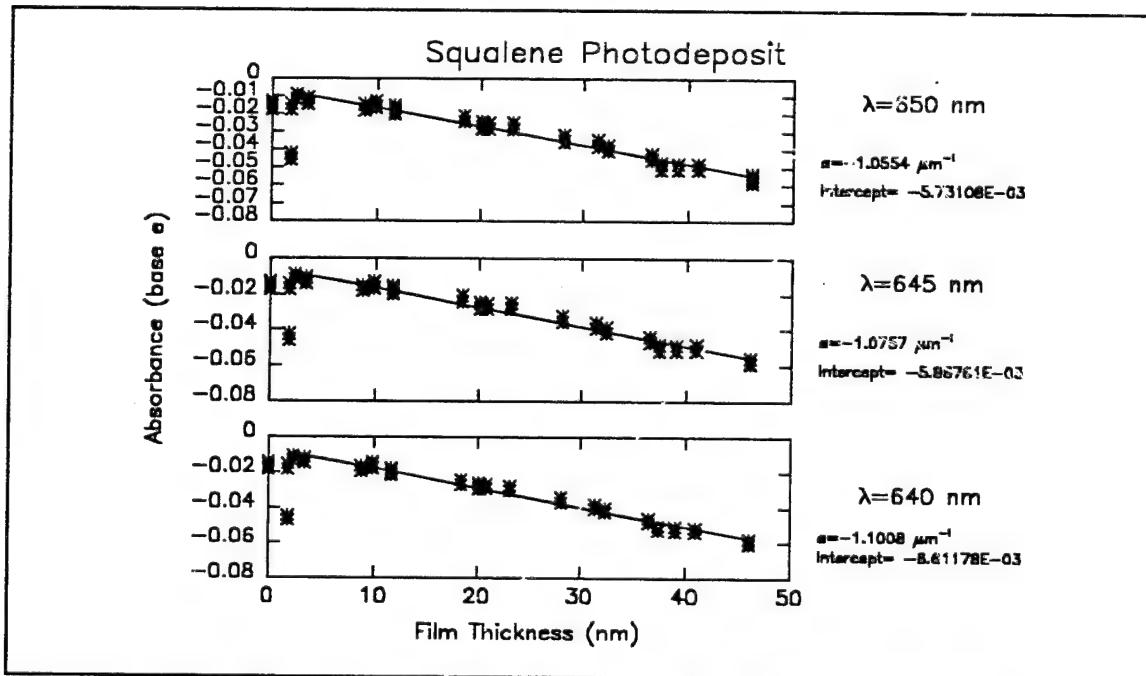


Figure D14d Fits of measured transmission spectra of the Squalene photodeposit to the Beer-Lambert absorption law. (Visible wavelength range)

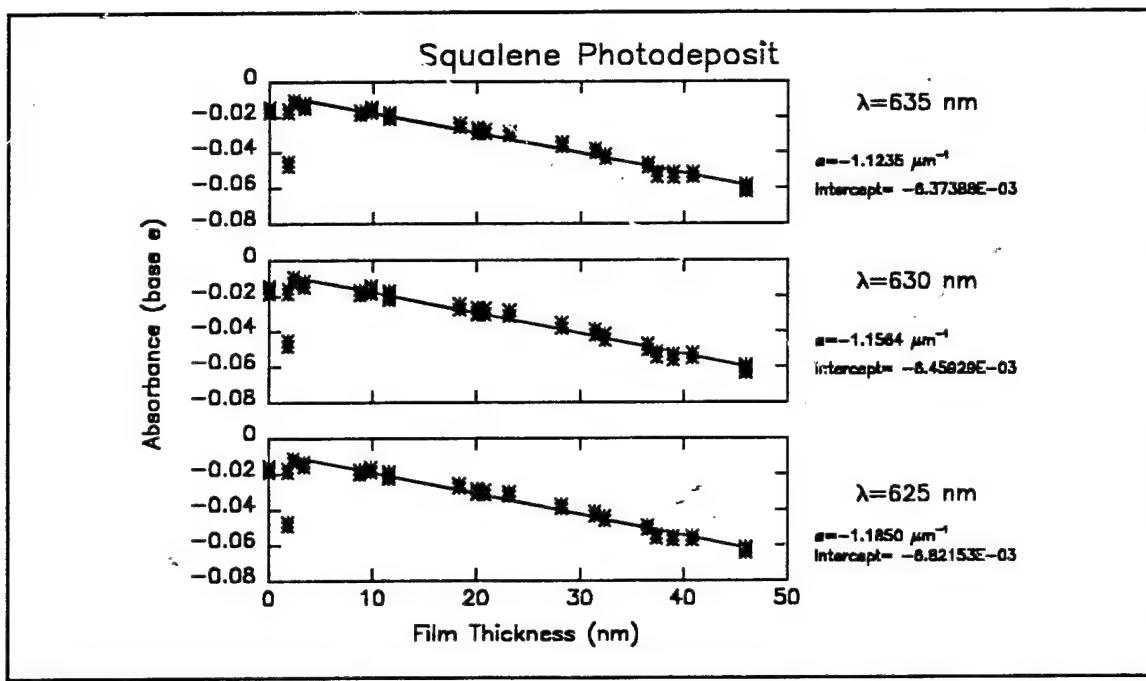


Figure D14e Fits of measured transmission spectra of the Squalene photodeposit to the Beer-Lambert absorption law. (Visible wavelength range)

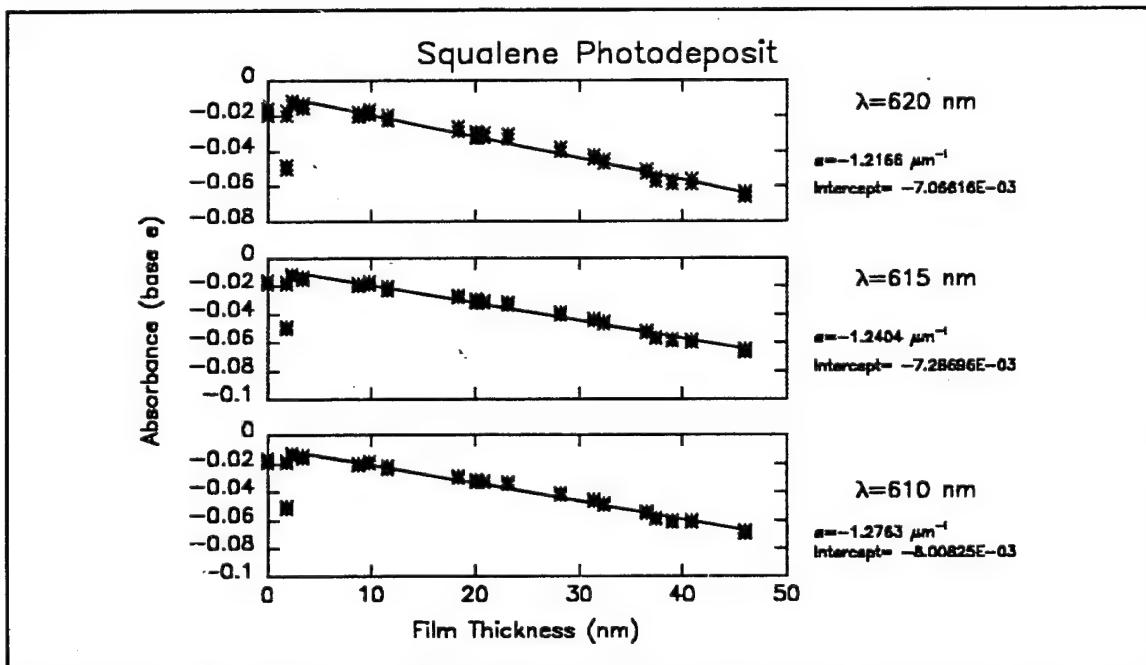


Figure D14f Fits of measured transmission spectra of the Squalene photodeposit to the Beer-Lambert absorption law. (Visible wavelength range)

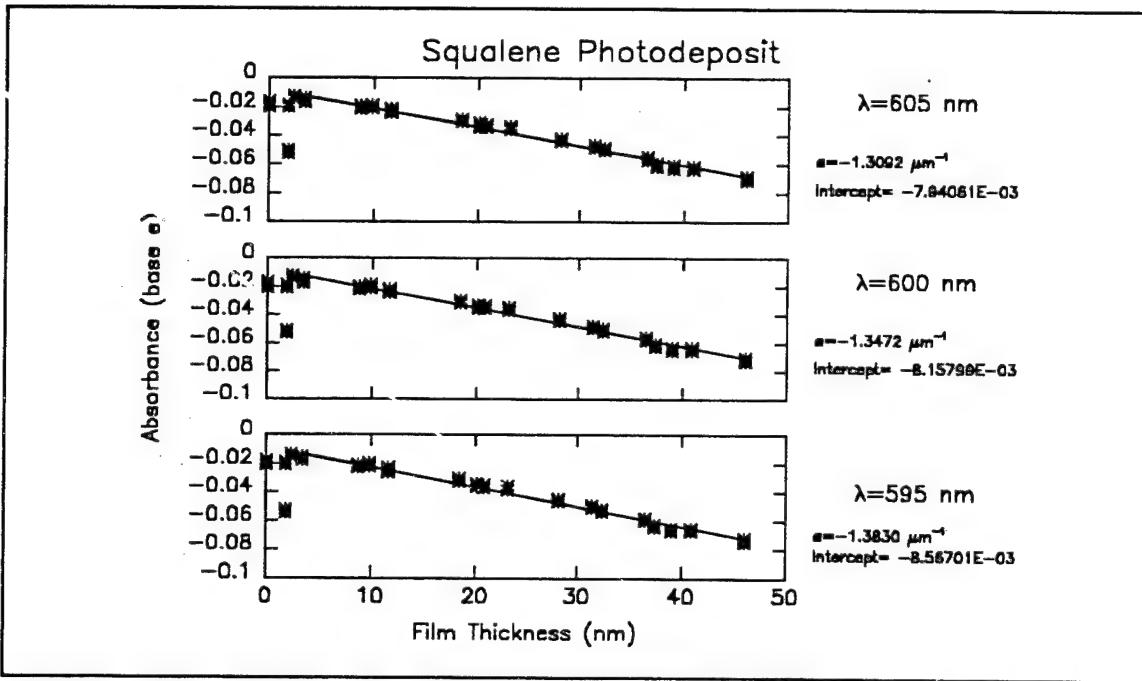


Figure D14g Fits of measured transmission spectra of the Squalene photodeposit to the Beer-Lambert absorption law. (Visible wavelength range)

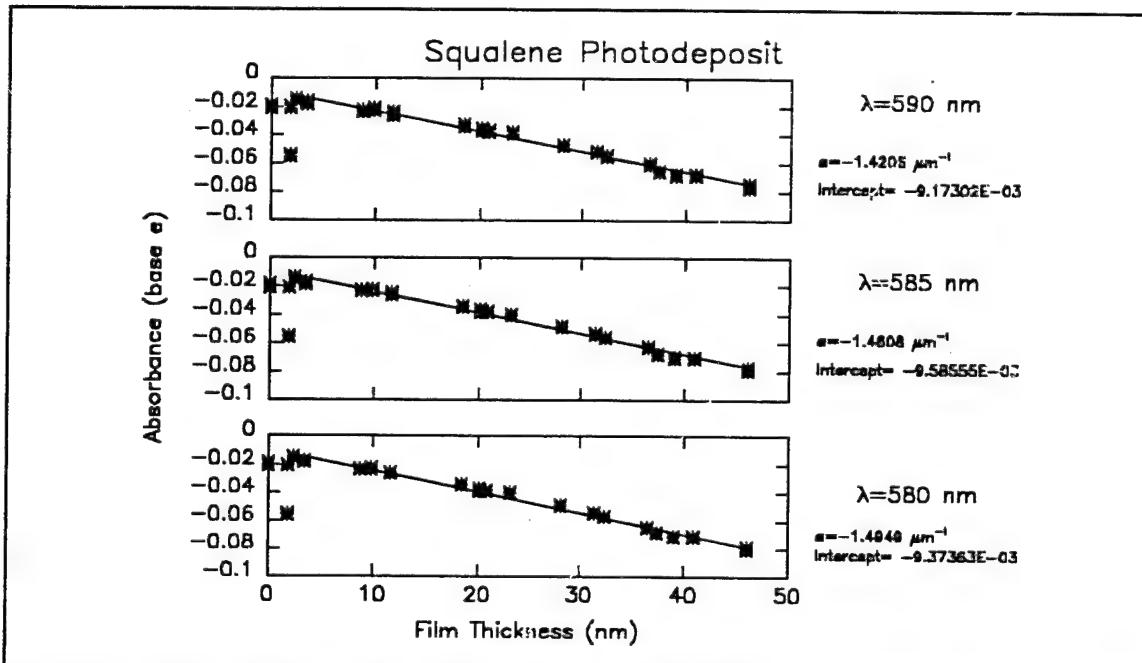


Figure D14h Fits of measured transmission spectra of the Squalene photodeposit to the Beer-Lambert absorption law. (Visible wavelength range)

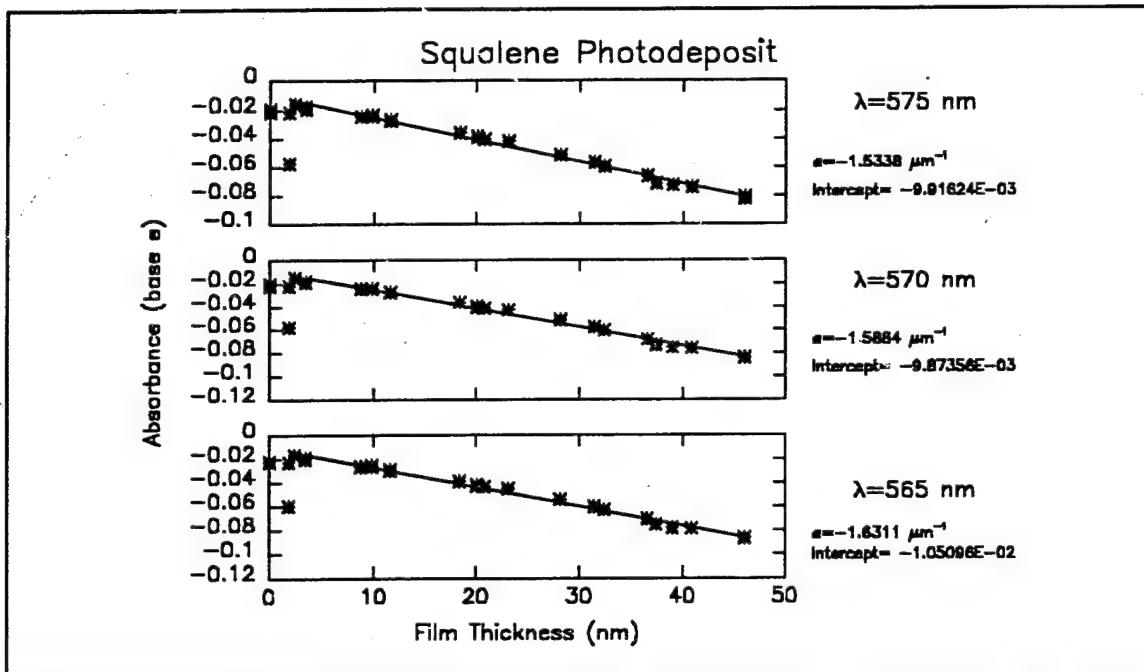


Figure D14i Fits of measured transmission spectra of the Squalene photodeposit to the Beer-Lambert absorption law. (Visible wavelength range)

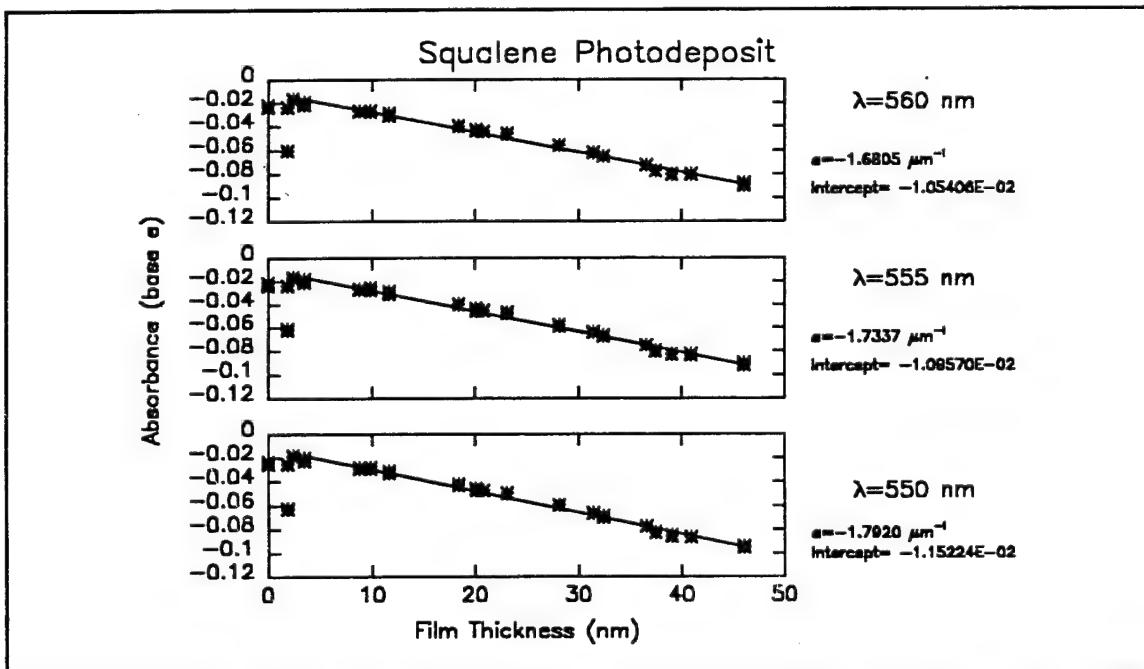


Figure D14j Fits of measured transmission spectra of the Squalene photodeposit to the Beer-Lambert absorption law. (Visible wavelength range)

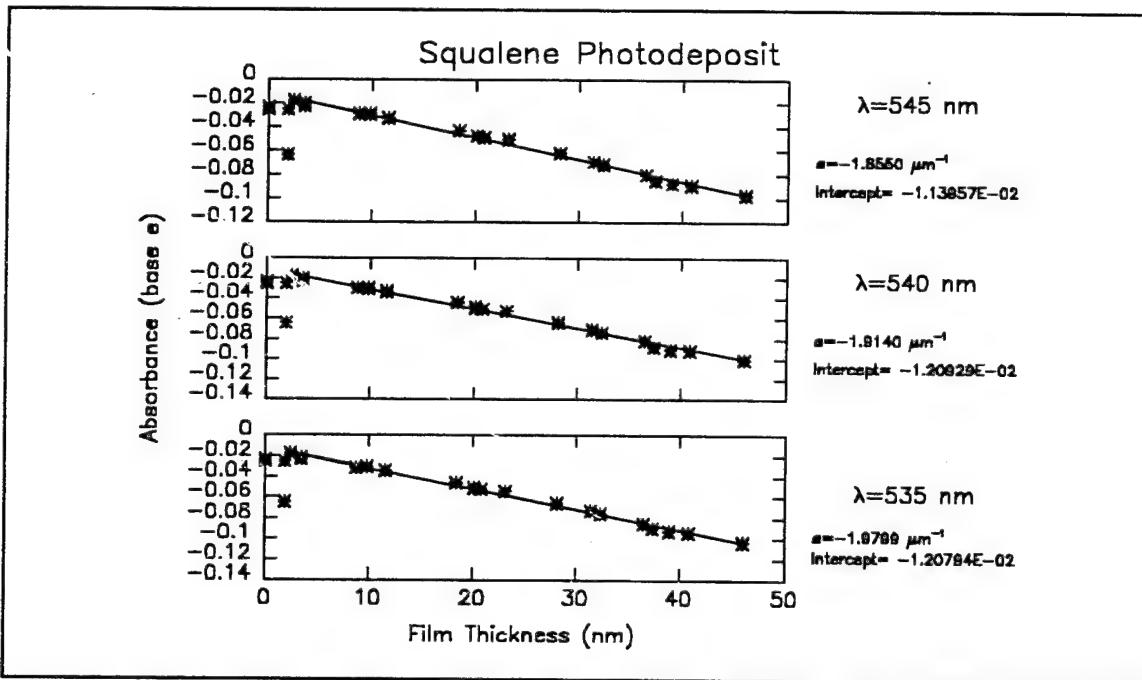


Figure D14k Fits of measured transmission spectra of the Squalene photodeposit to the Beer-Lambert absorption law. (Visible wavelength range)

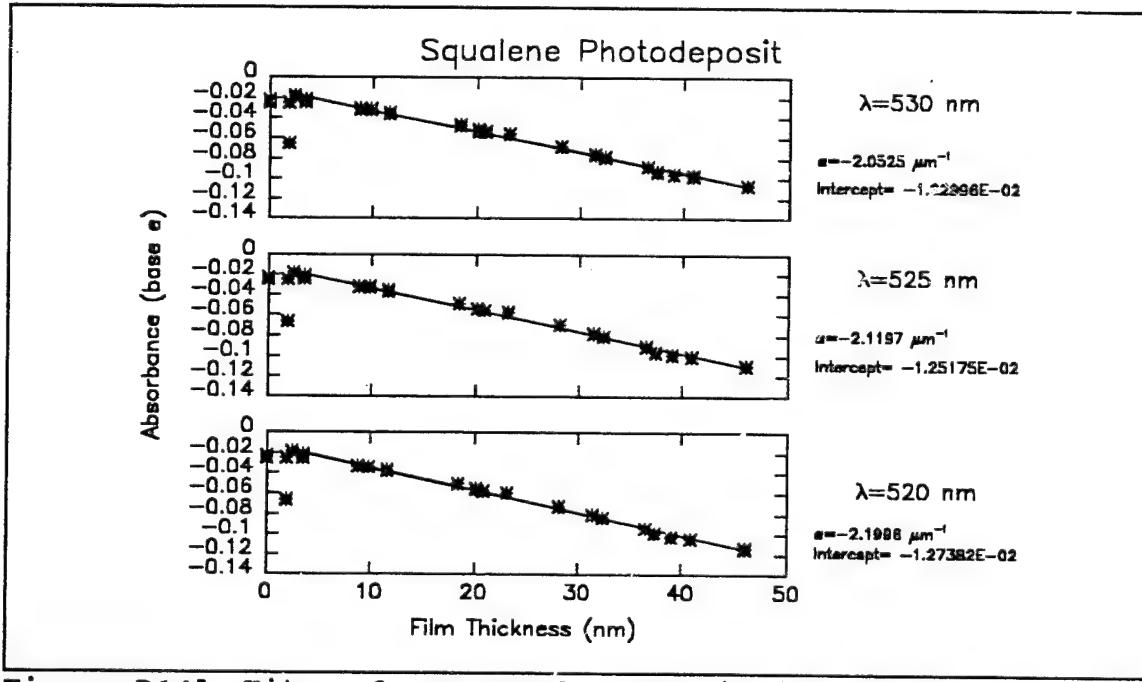


Figure D14l Fits of measured transmission spectra of the Squalene photodeposit to the Beer-Lambert absorption law. (Visible wavelength range)

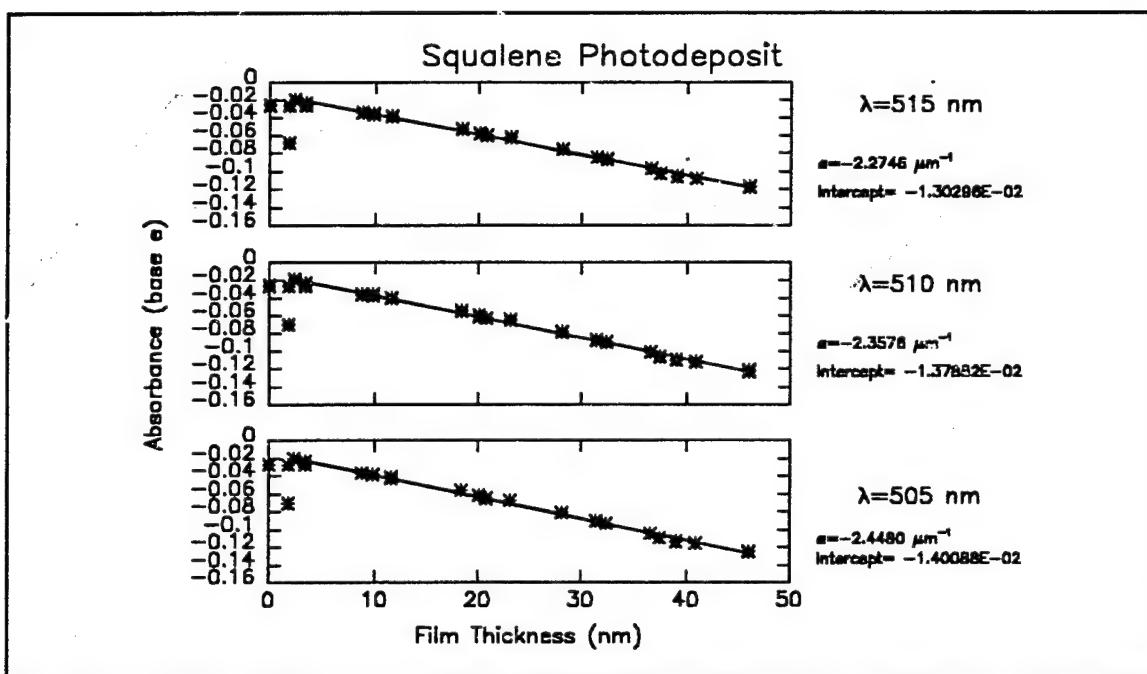


Figure D14m Fits of measured transmission spectra of the Squalene photodeposit to the Beer-Lambert absorption law. (Visible wavelength range)

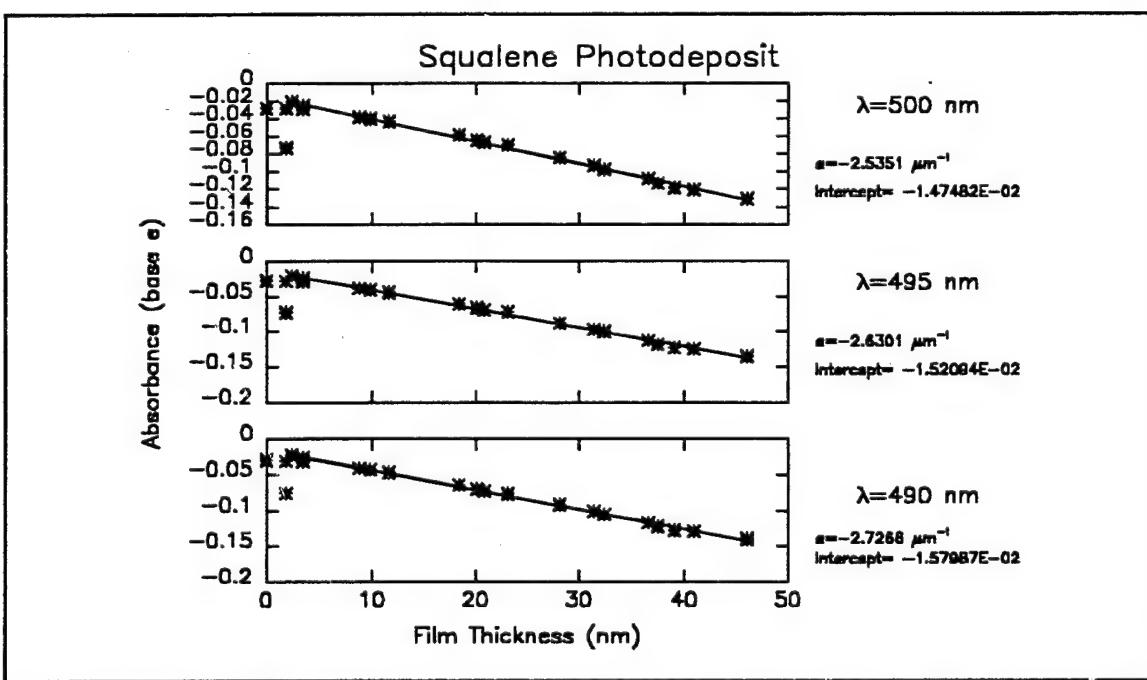


Figure D14n Fits of measured transmission spectra of the Squalene photodeposit to the Beer-Lambert absorption law. (Visible wavelength range)

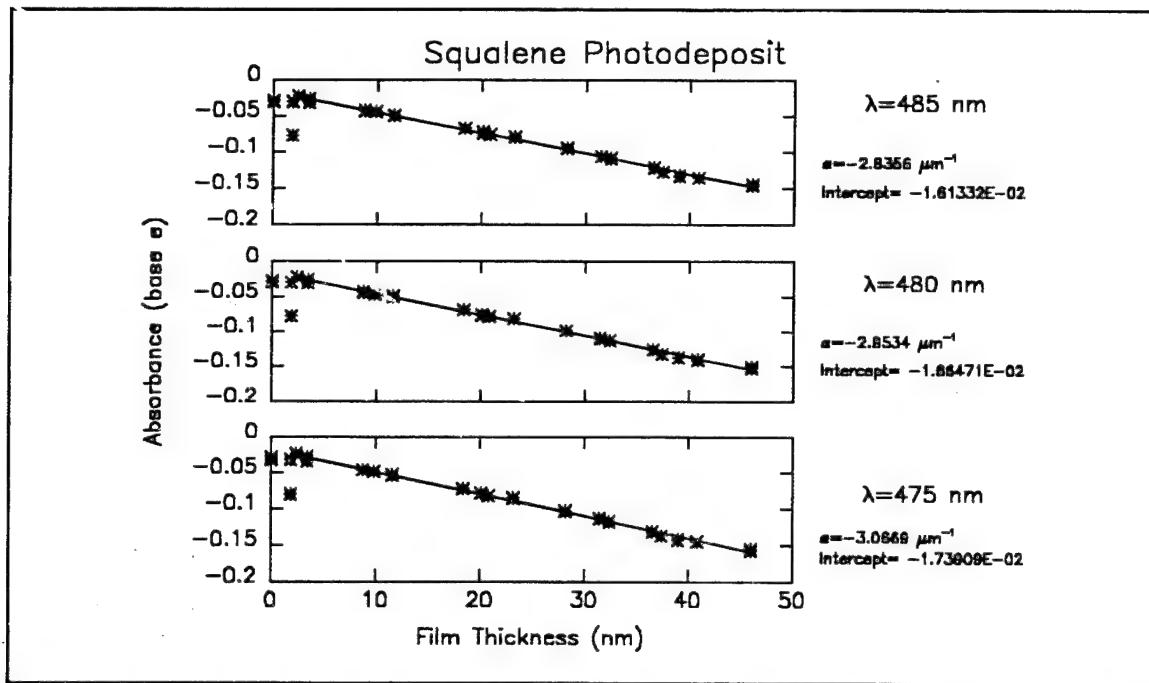


Figure D14o Fits of measured transmission spectra of the Squalene photodeposit to the Beer-Lambert absorption law. (Visible wavelength range)

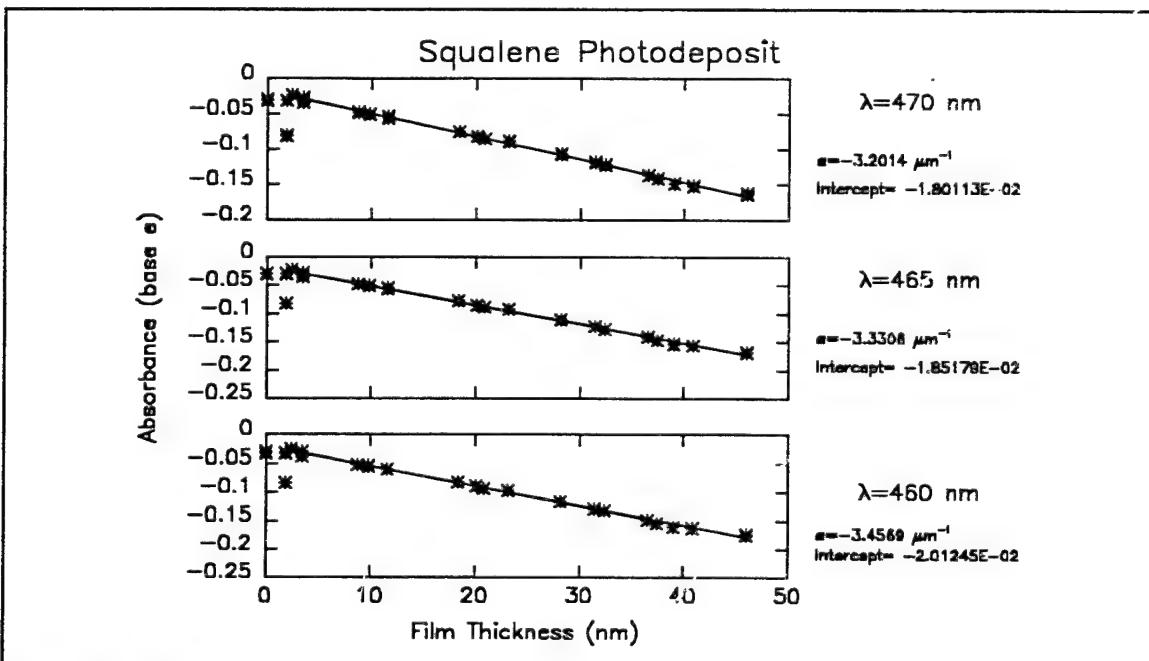


Figure D14p Fits of measured transmission spectra of the Squalene photodeposit to the Beer-Lambert absorption law. (Visible wavelength range)

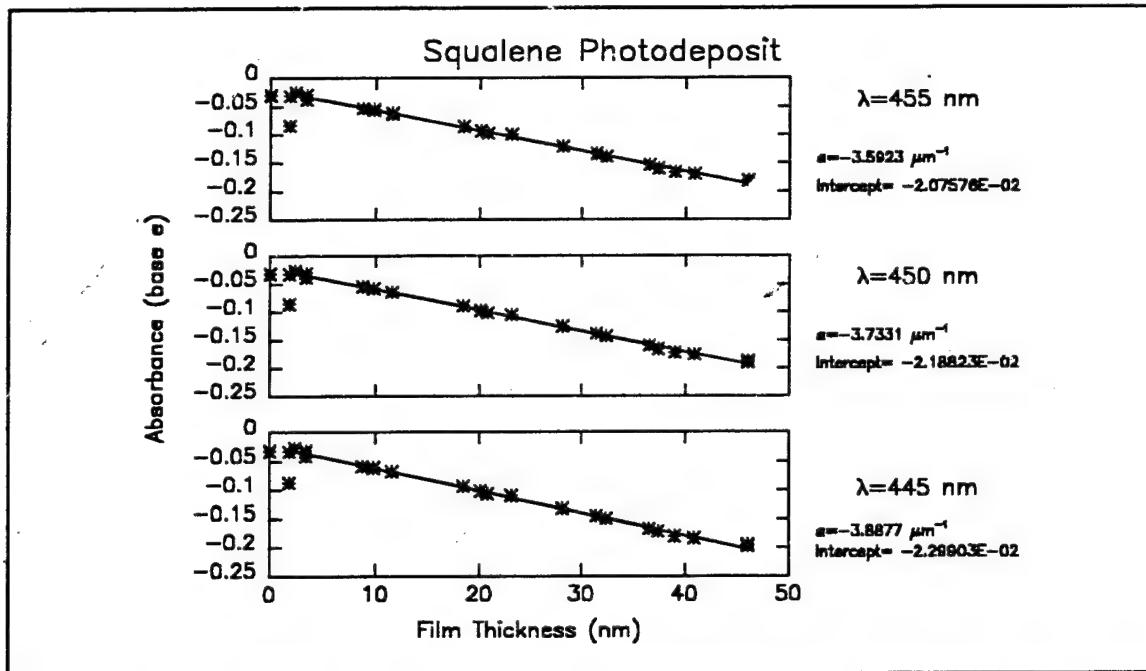


Figure D14q Fits of measured transmission spectra of the Squalene photodeposit to the Beer-Lambert absorption law. (Visible wavelength range)

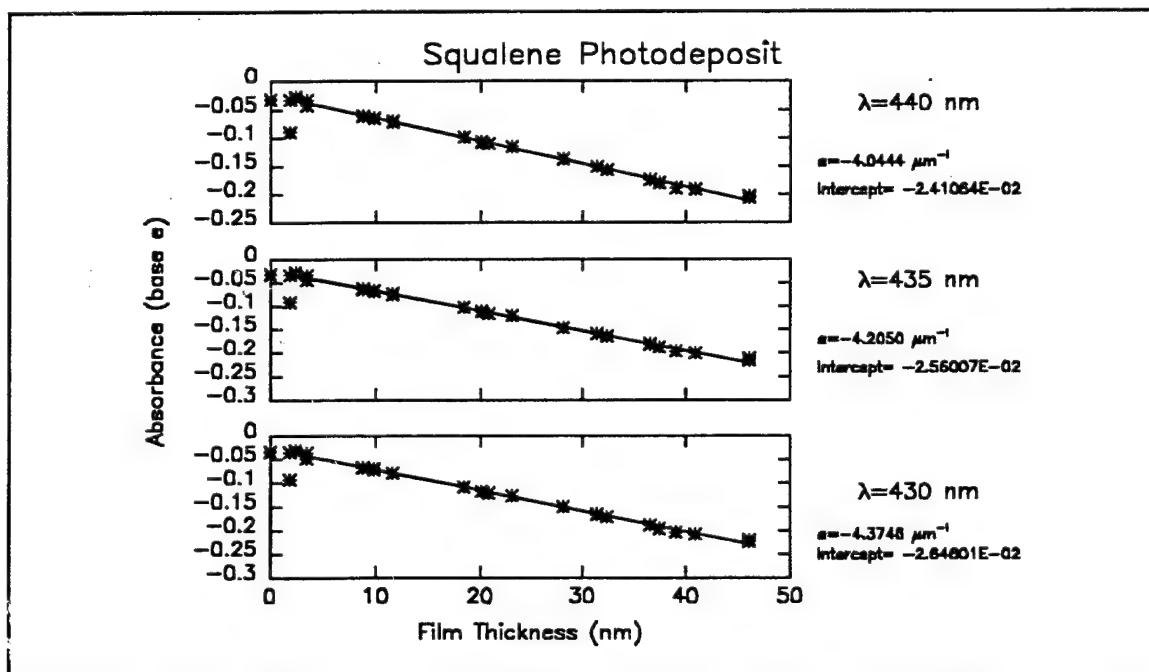


Figure D14r Fits of measured transmission spectra of the Squalene photodeposit to the Beer-Lambert absorption law. (Visible wavelength range)

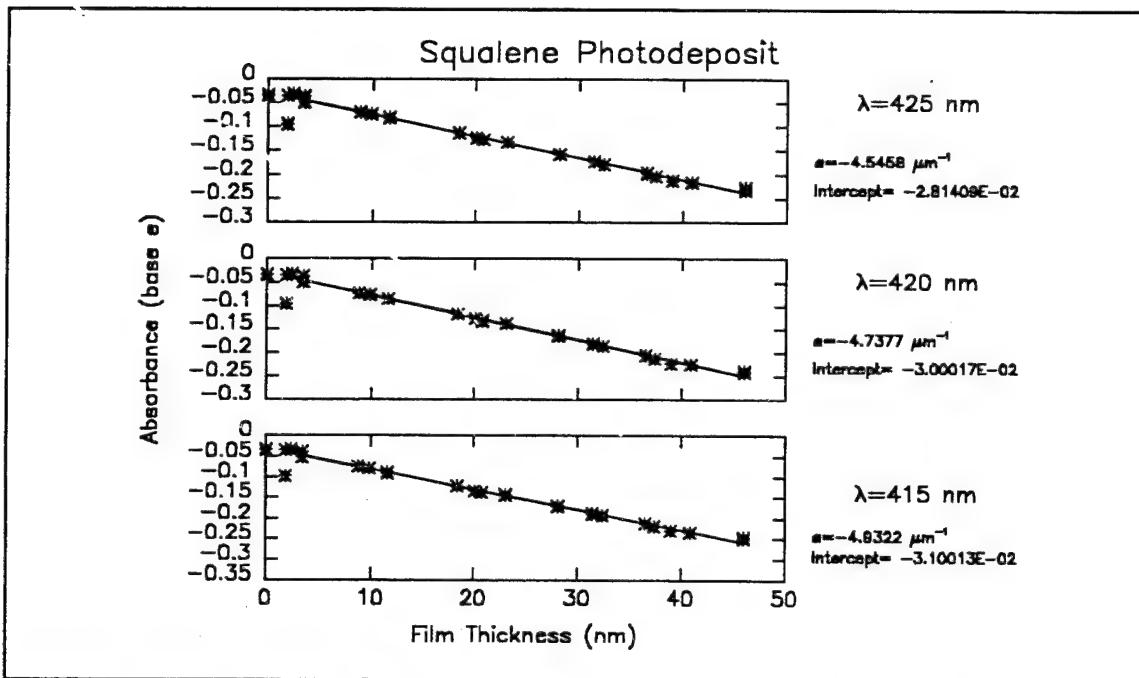


Figure D14s Fits of measured transmission spectra of the Squalene photodeposit to the Beer-Lambert absorption law. (Visible wavelength range)

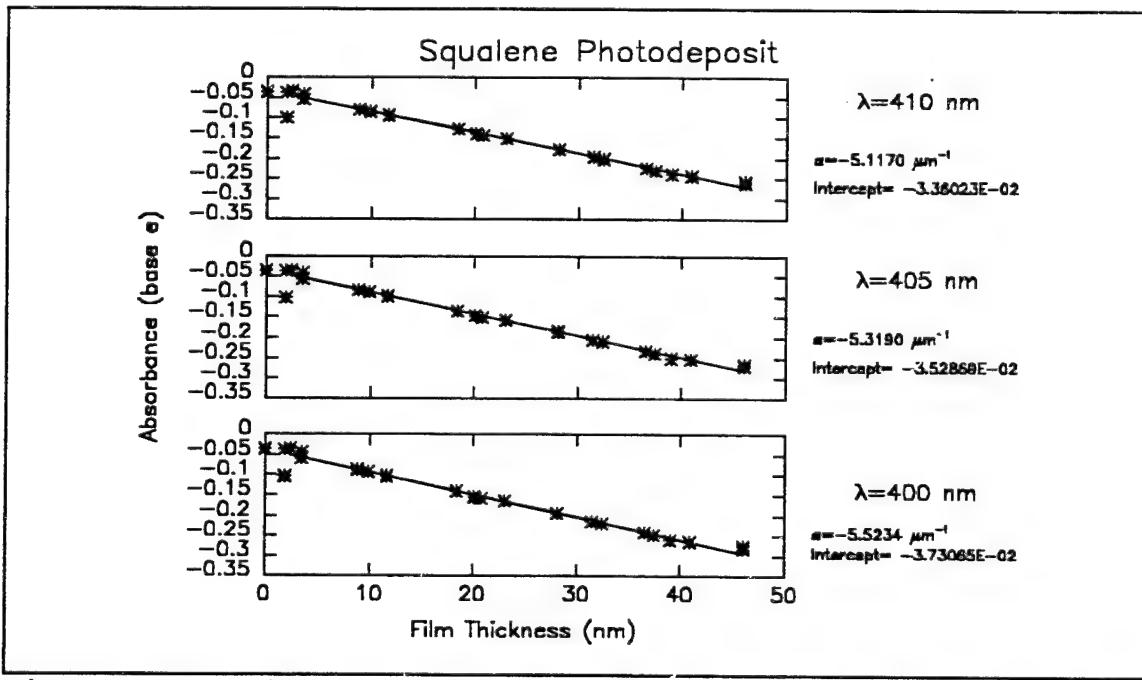


Figure D14t Fits of measured transmission spectra of the Squalene photodeposit to the Beer-Lambert absorption law. (Visible wavelength range)

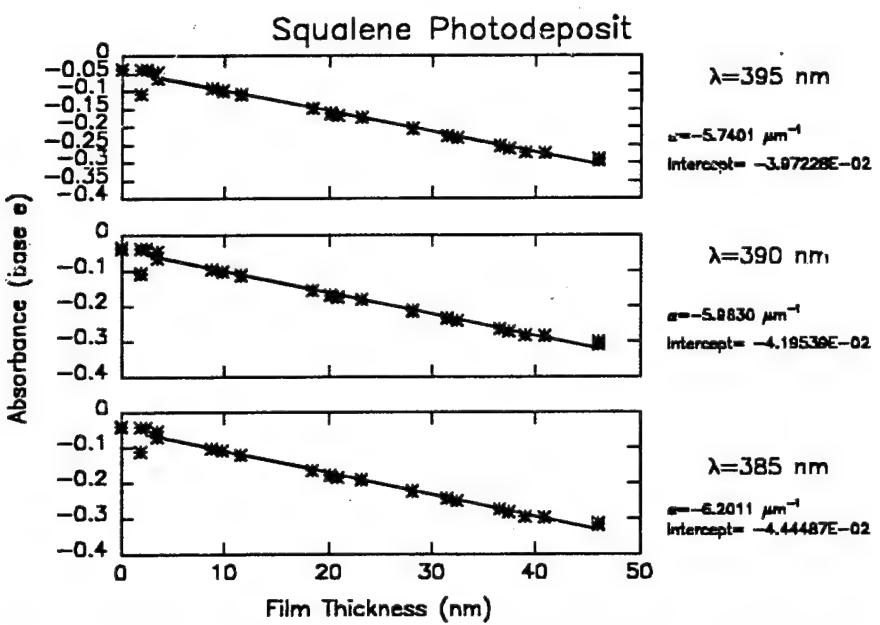


Figure D14u Fits of measured transmission spectra of the Squalene photodeposit to the Beer-Lambert absorption law. (Visible wavelength range)

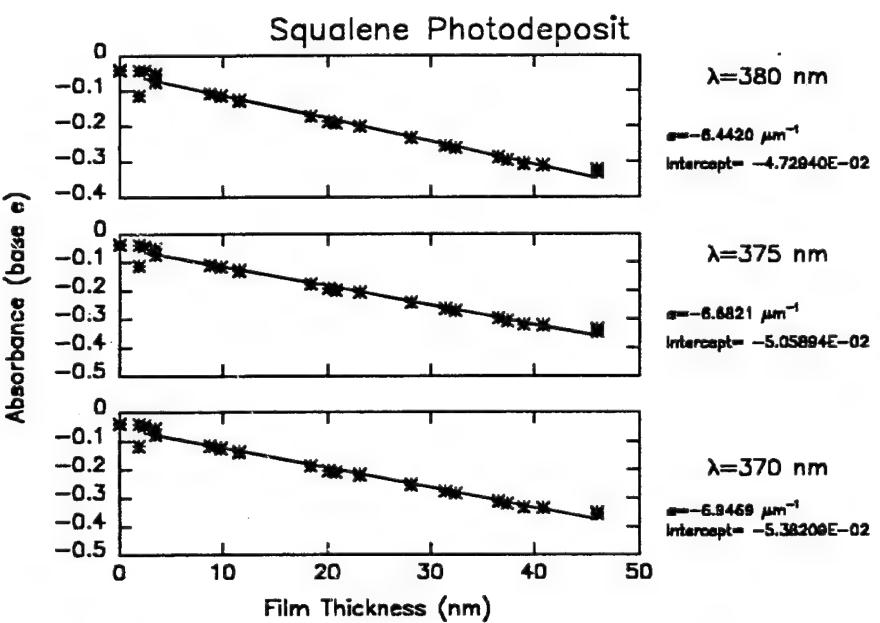


Figure D14v Fits of measured transmission spectra of the Squalene photodeposit to the Beer-Lambert absorption law. (Visible wavelength range)

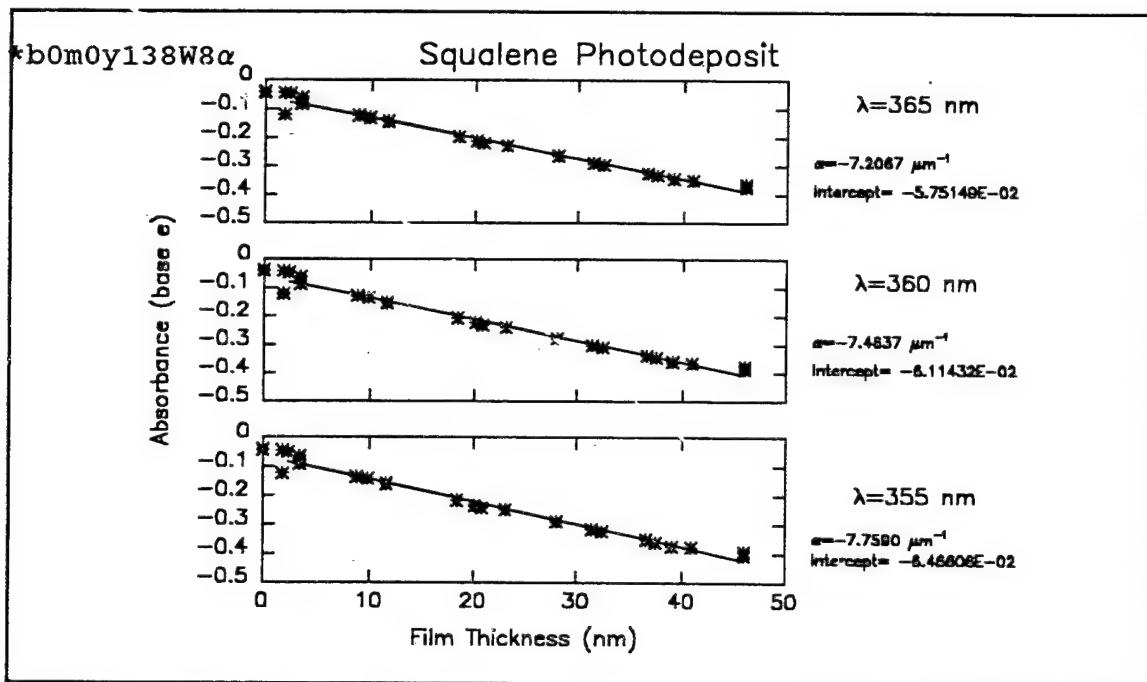


Figure D14w Fits of measured transmission spectra of the Squalene photodeposit to the Beer-Lambert absorption law. (Visible wavelength range)

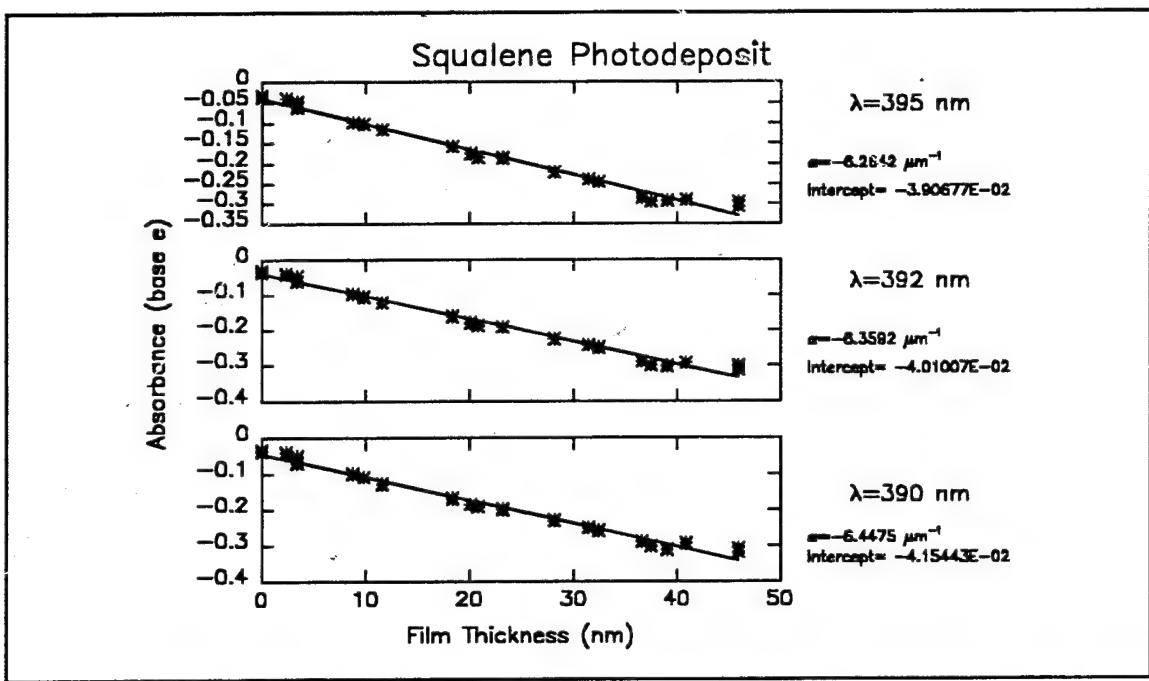


Figure D15a Fits of measured transmission spectra of the Squalene photodeposit to the Beer-Lambert absorption law. (Ultraviolet wavelength range)

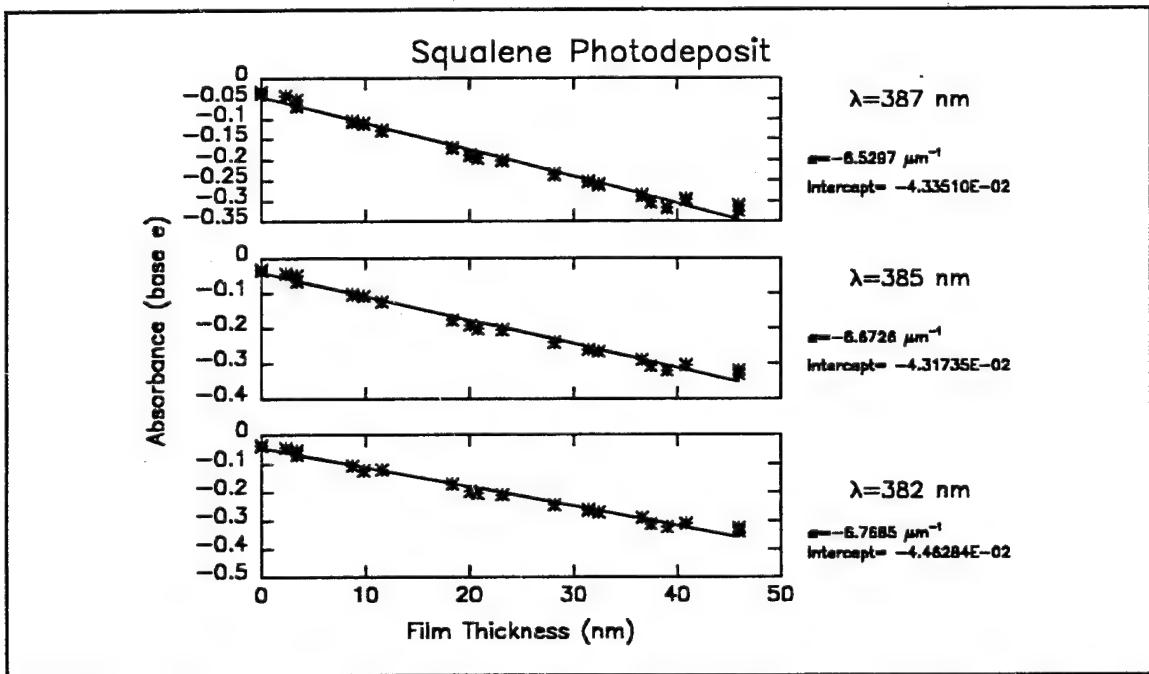


Figure D15b Fits of measured transmission spectra of the Squalene photodeposit to the Beer-Lambert absorption law. (Ultraviolet wavelength range)

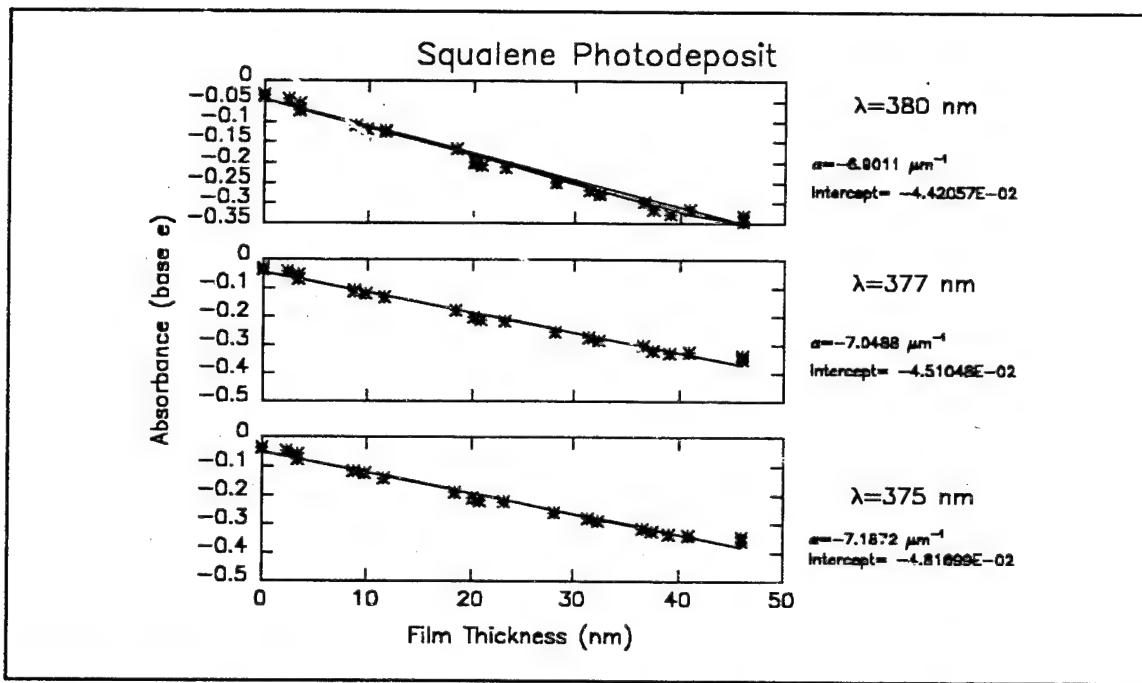


Figure D15c Fits of measured transmission spectra of the Squalene photodeposit to the Beer-Lambert absorption law. (Ultraviolet wavelength range)

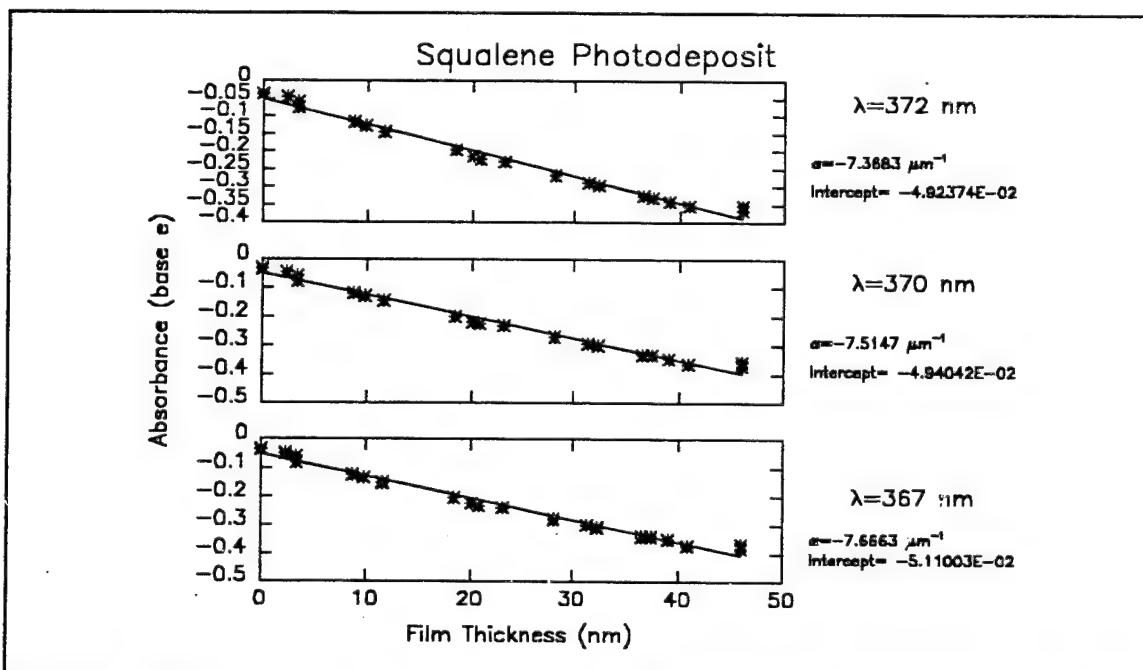


Figure D15d Fits of measured transmission spectra of the Squalene photodeposit to the Beer-Lambert absorption law. (Ultraviolet wavelength range)

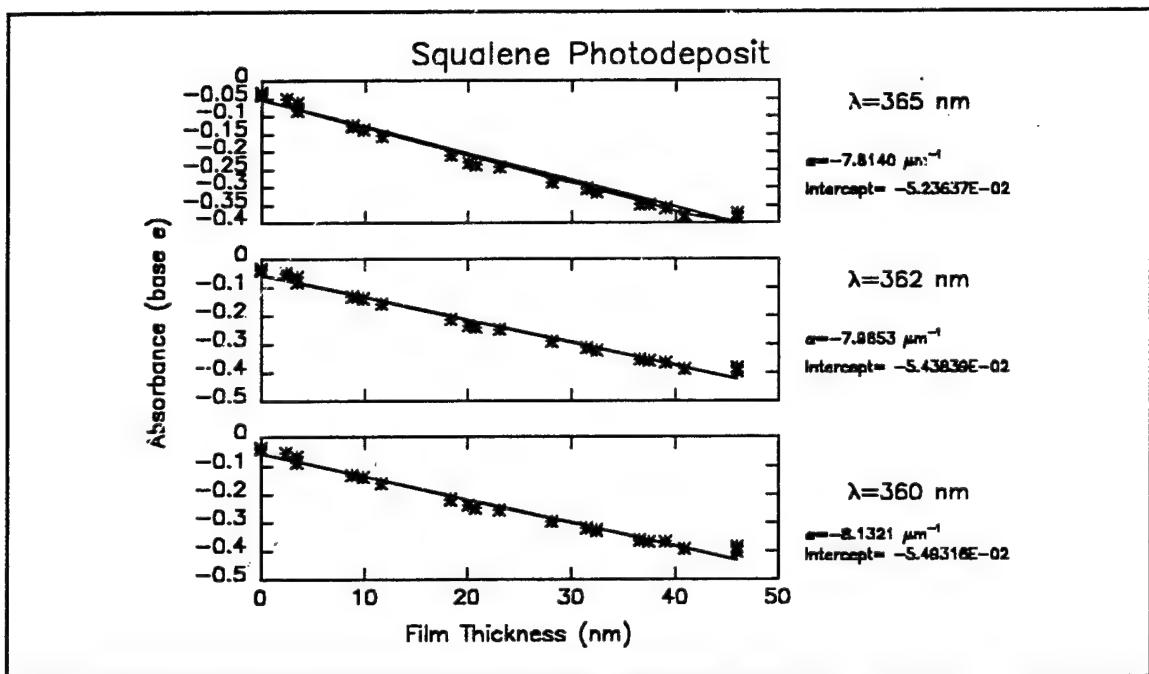


Figure D15e Fits of measured transmission spectra of the Squalene photodeposit to the Beer-Lambert absorption law. (Ultraviolet wavelength range)

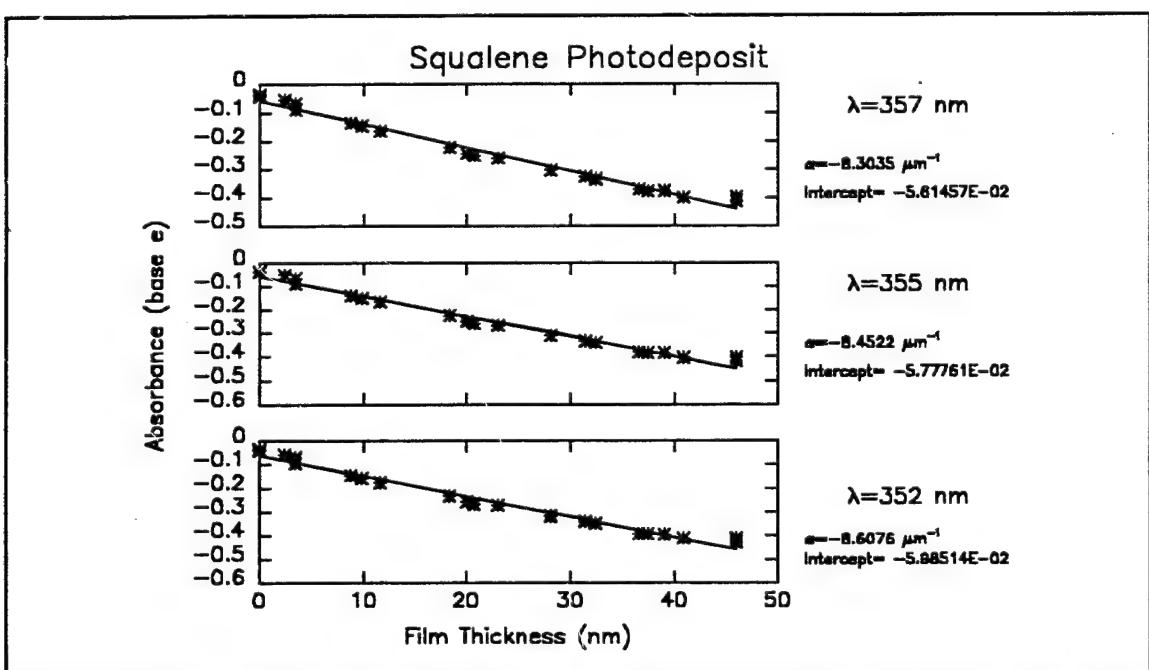


Figure D15f Fits of measured transmission spectra of the Squalene photodeposit to the Beer-Lambert absorption law. (Ultraviolet wavelength range)

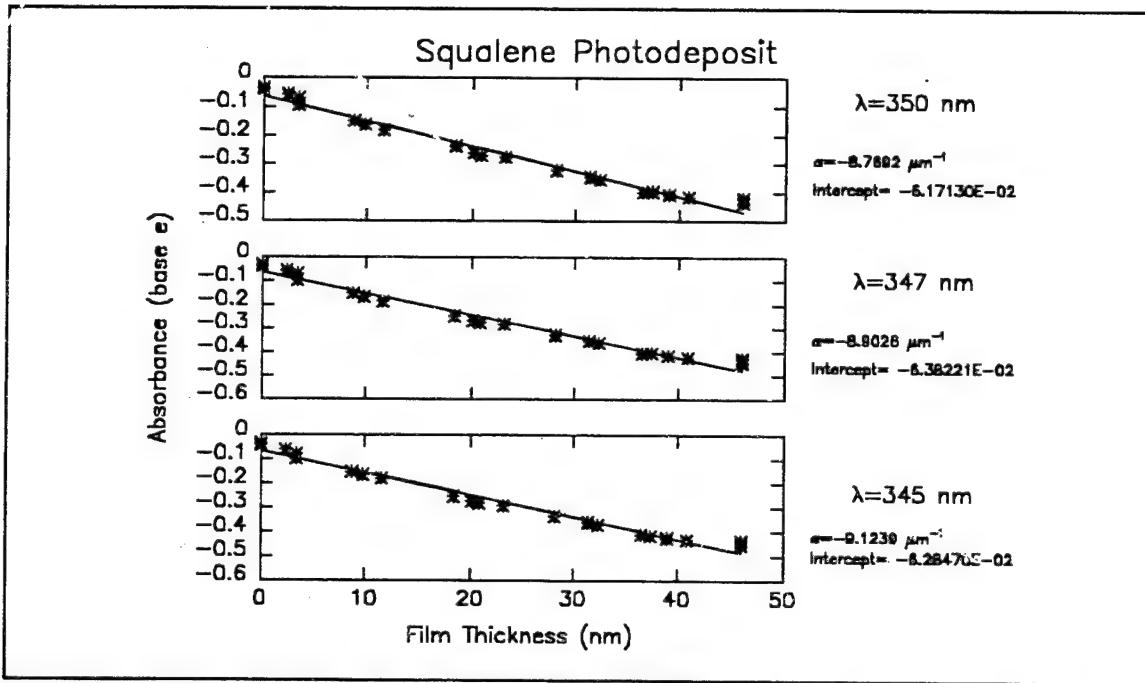


Figure D15g Fits of measured transmission spectra of the Squalene photodeposit to the Beer-Lambert absorption law. (Ultraviolet wavelength range)

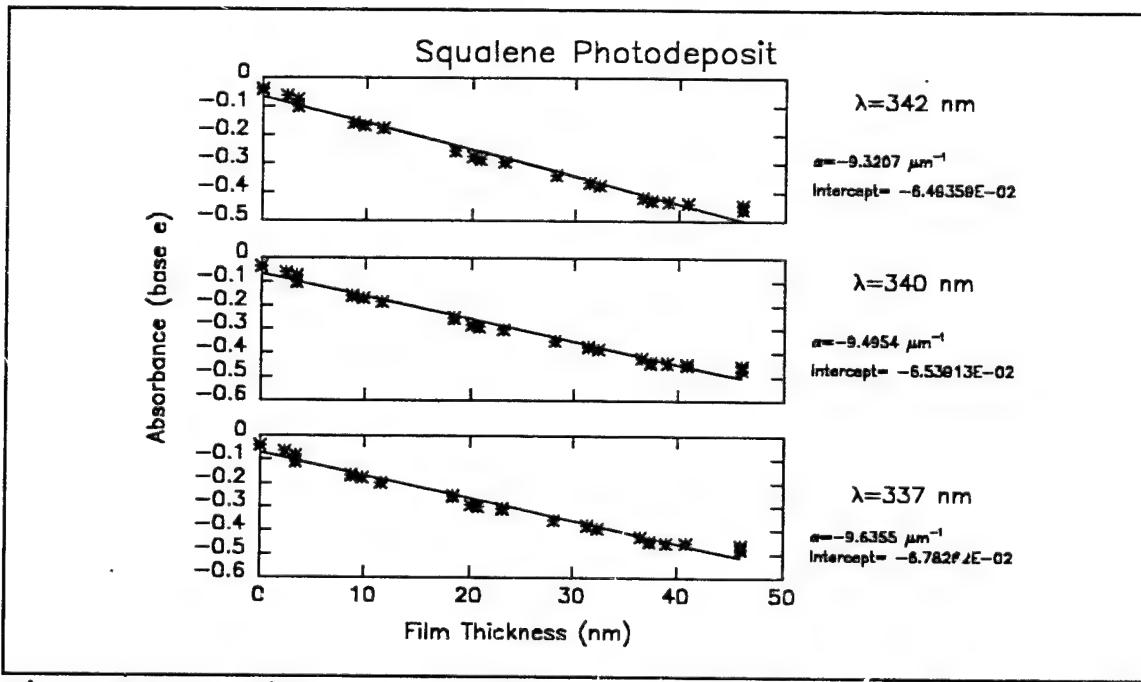


Figure D15h Fits of measured transmission spectra of the Squalene photodeposit to the Beer-Lambert absorption law. (Ultraviolet wavelength range)

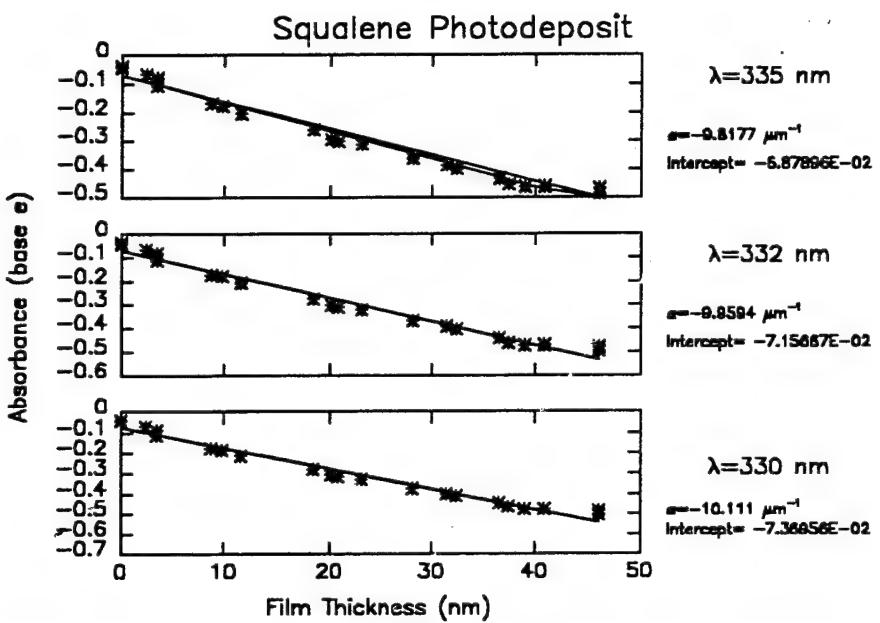


Figure D15i Fits of measured transmission spectra of the Squalene photodeposit to the Beer-Lambert absorption law. (Ultraviolet wavelength range)

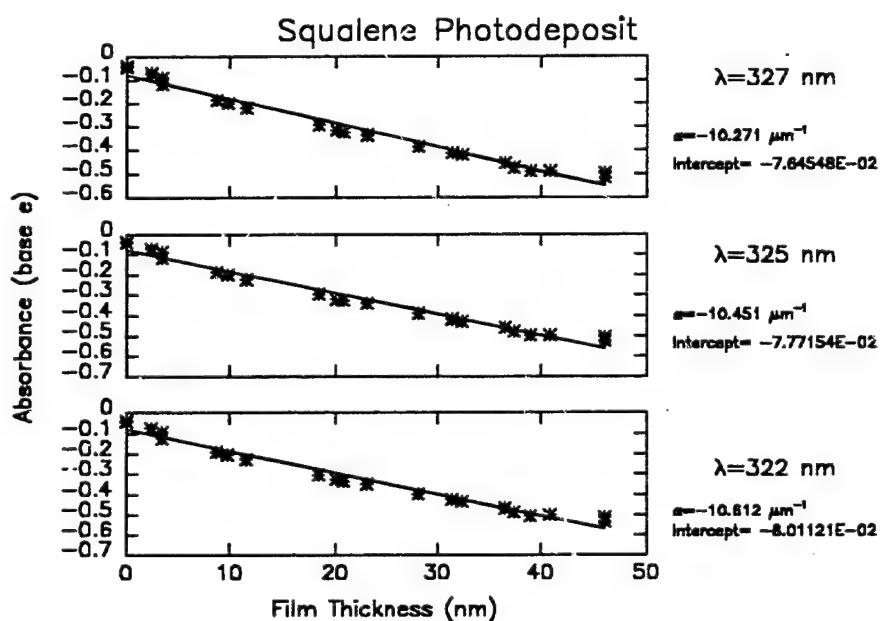


Figure D15j Fits of measured transmission spectra of the Squalene photodeposit to the Beer-Lambert absorption law. (Ultraviolet wavelength range)

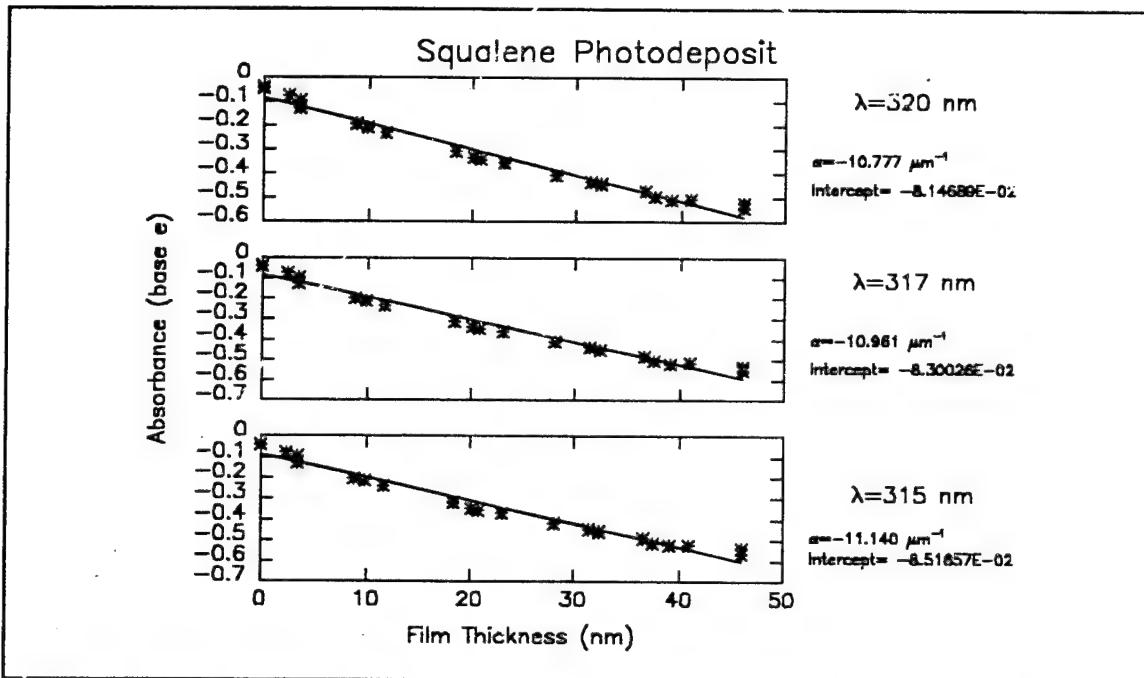


Figure D15k Fits of measured transmission spectra of the Squalene photodeposit to the Beer-Lambert absorption law. (Ultraviolet wavelength range)

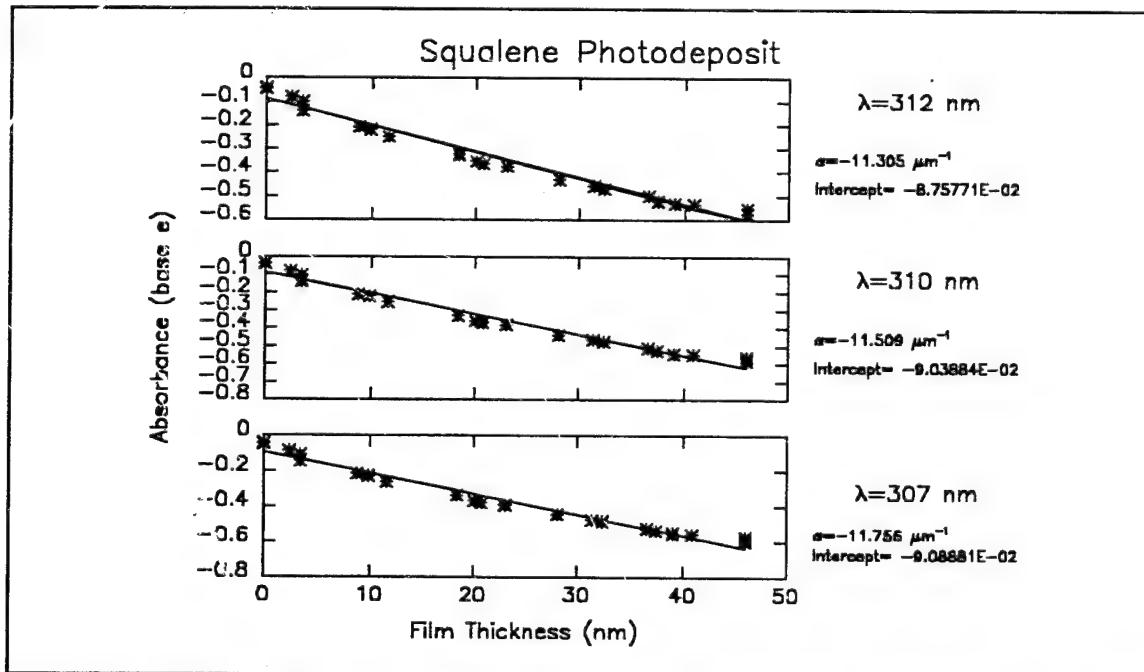


Figure D15l Fits of measured transmission spectra of the Squalene photodeposit to the Beer-Lambert absorption law. (Ultraviolet wavelength range)

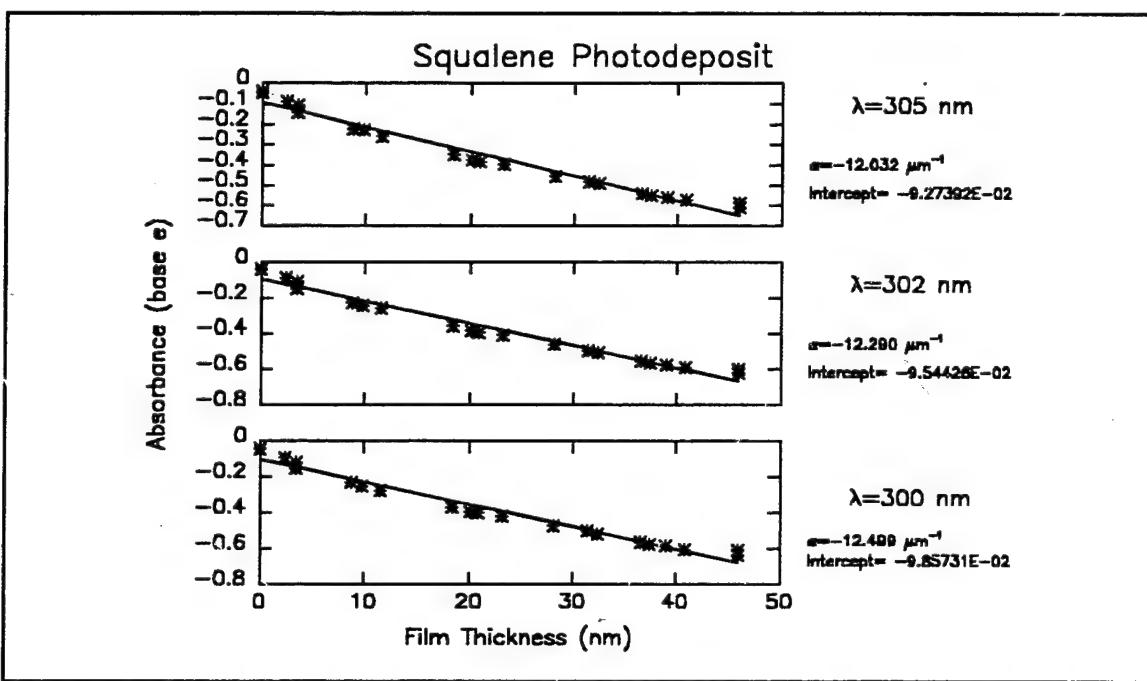


Figure D15m Fits of measured transmission spectra of the Squalene photodeposit to the Beer-Lambert absorption law. (Ultraviolet wavelength range)

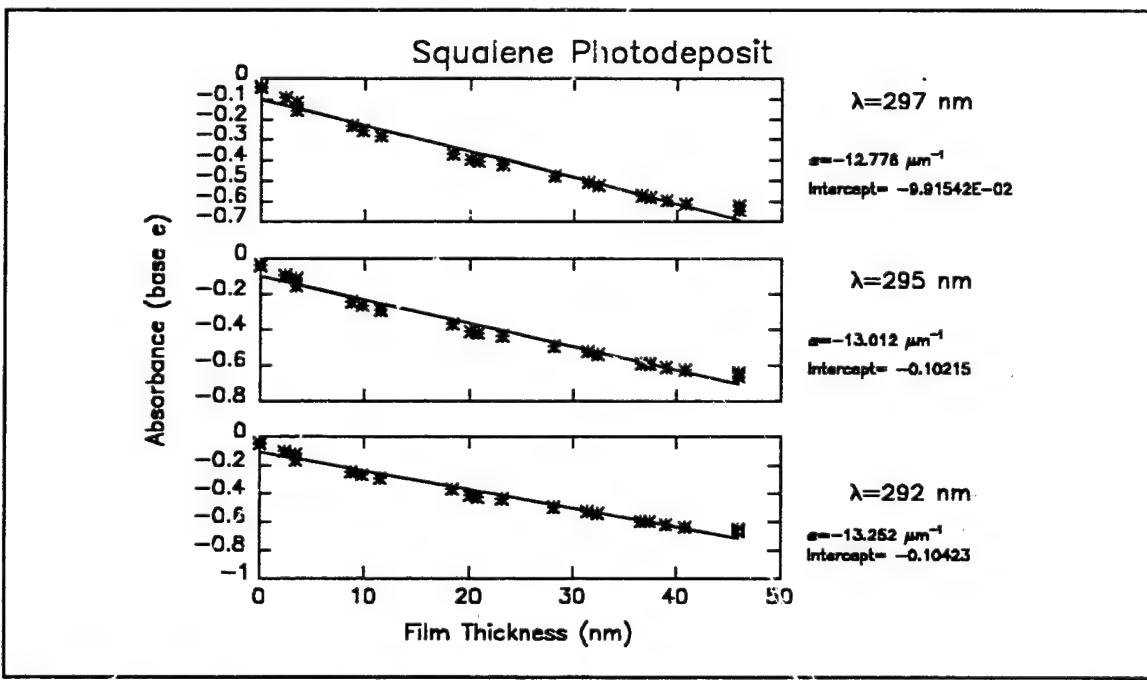


Figure D15n Fits of measured transmission spectra of the Squalene photodeposit to the Beer-Lambert absorption law. (Ultraviolet wavelength range)

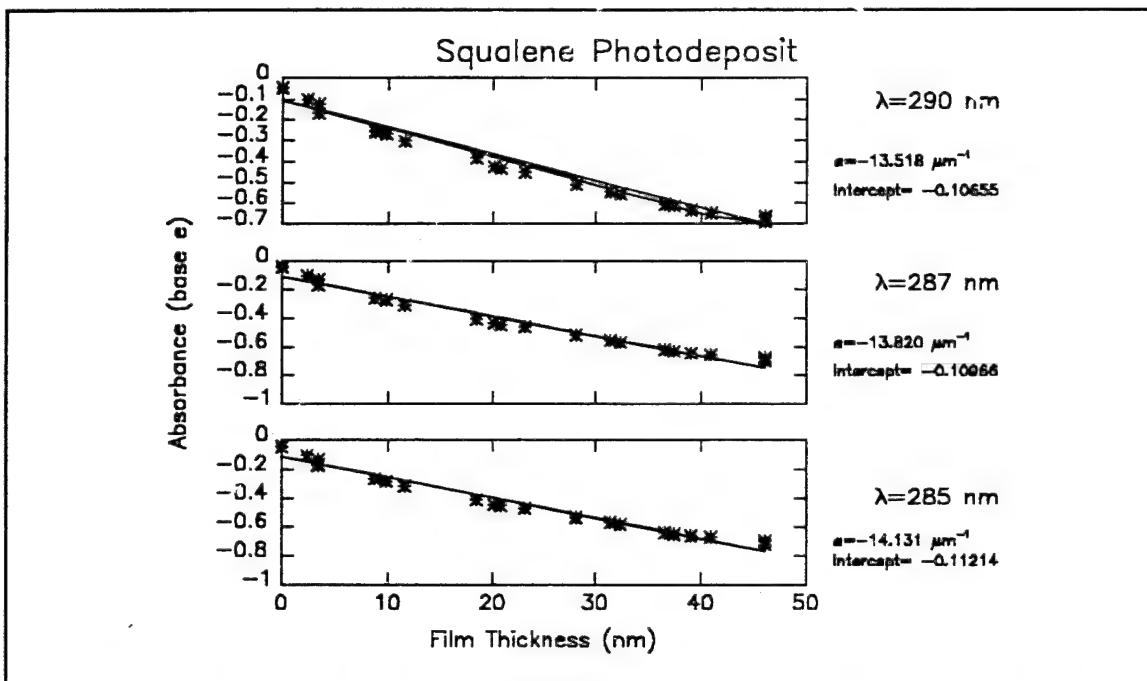


Figure D15o Fits of measured transmission spectra of the Squalene photodeposit to the Beer-Lambert absorption law. (Ultraviolet wavelength range)

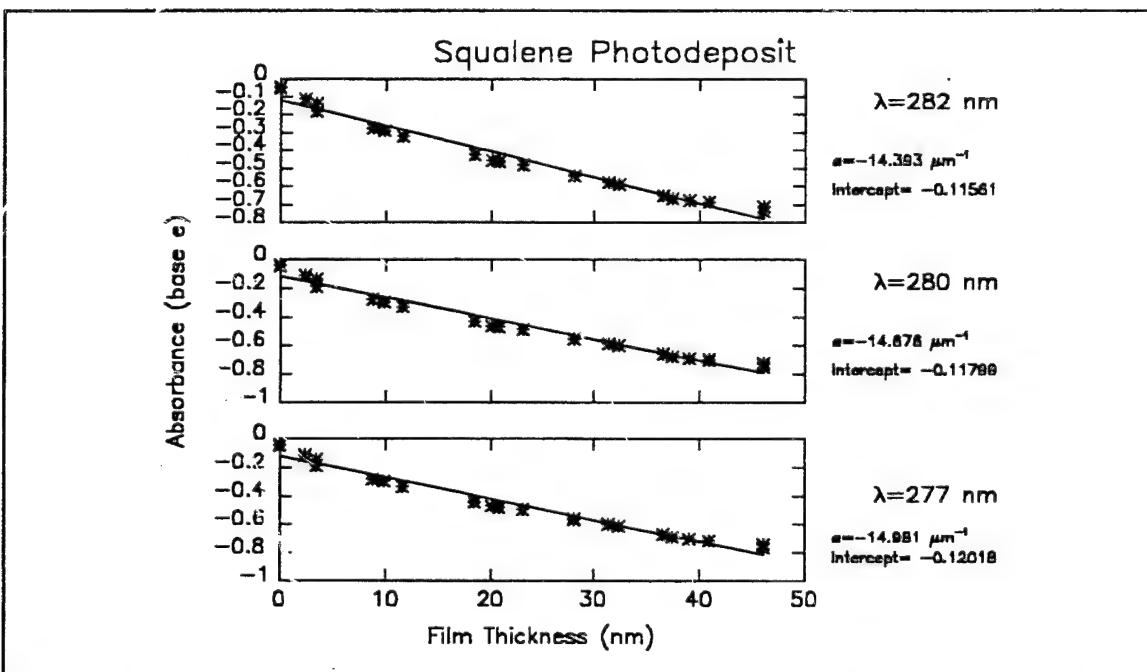


Figure D15p Fits of measured transmission spectra of the Squalene photodeposit to the Beer-Lambert absorption law. (Ultraviolet wavelength range)

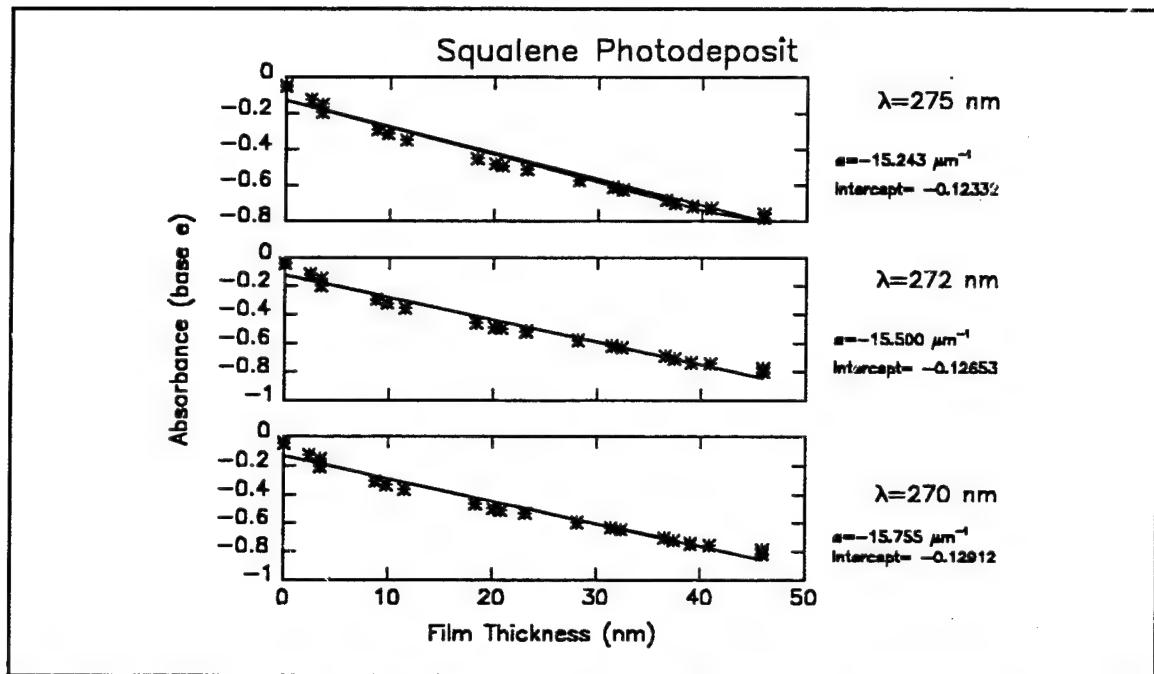


Figure D15q Fits of measured transmission spectra of the Squalene photodeposit to the Beer-Lambert absorption law. (Ultraviolet wavelength range)

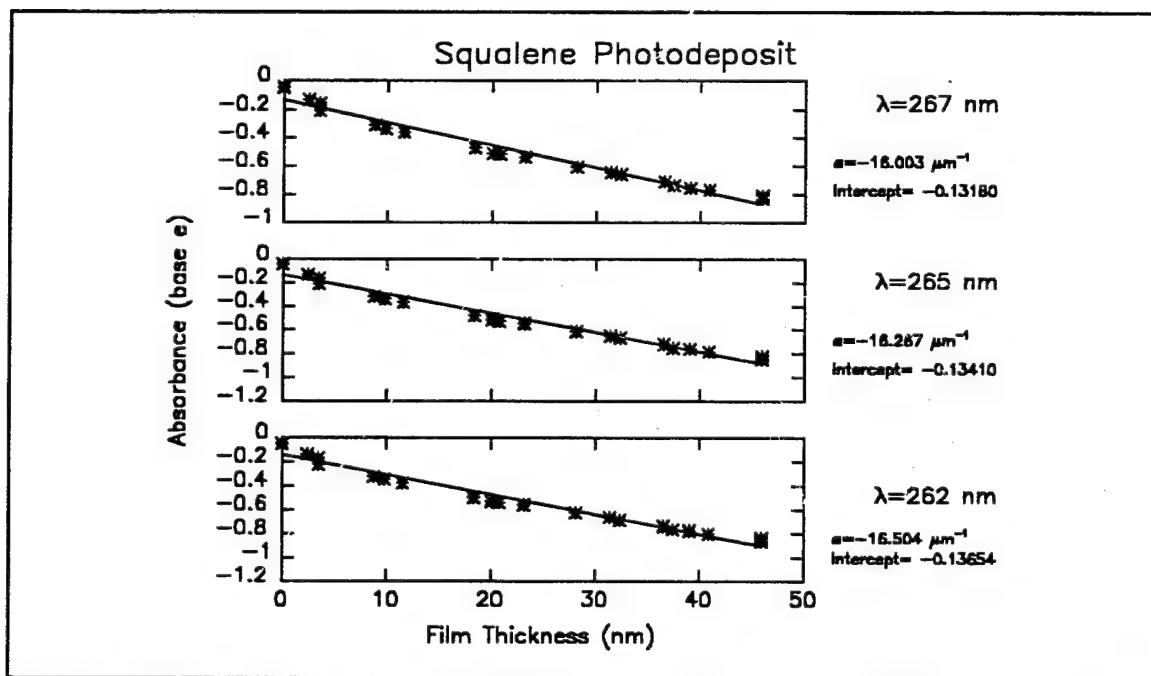


Figure D15r Fits of measured transmission spectra of the Squalene photodeposit to the Beer-Lambert absorption law. (Ultraviolet wavelength range)

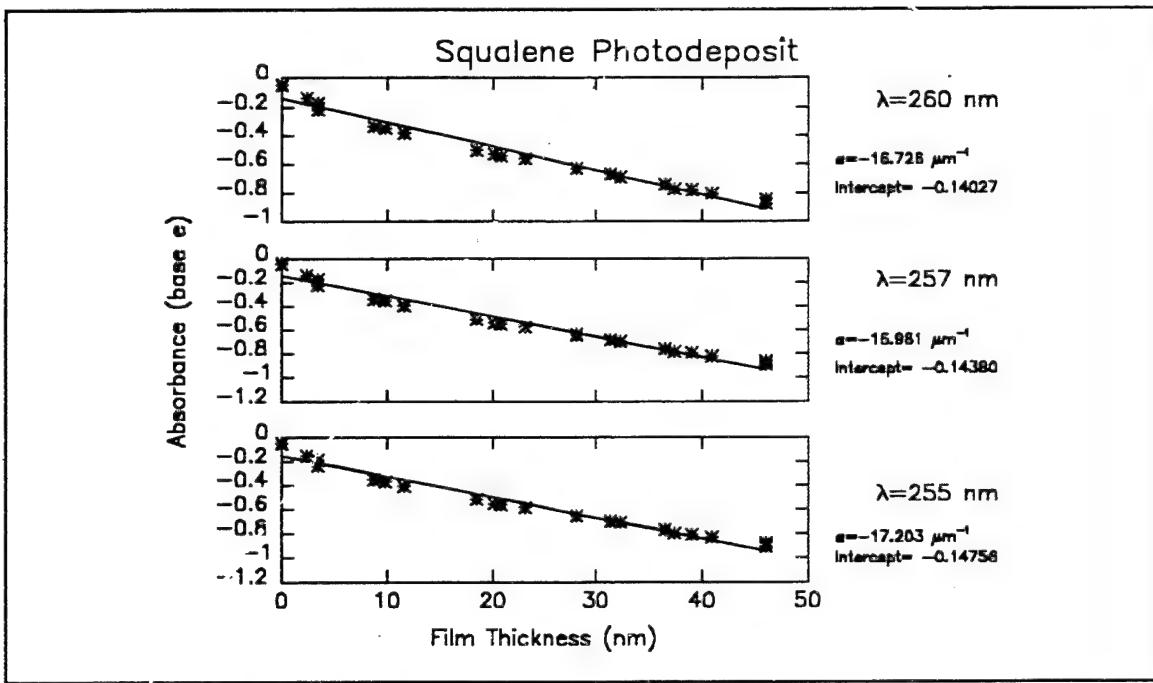


Figure D15s Fits of measured transmission spectra of the Squalene photodeposit to the Beer-Lambert absorption law. (Ultraviolet wavelength range)

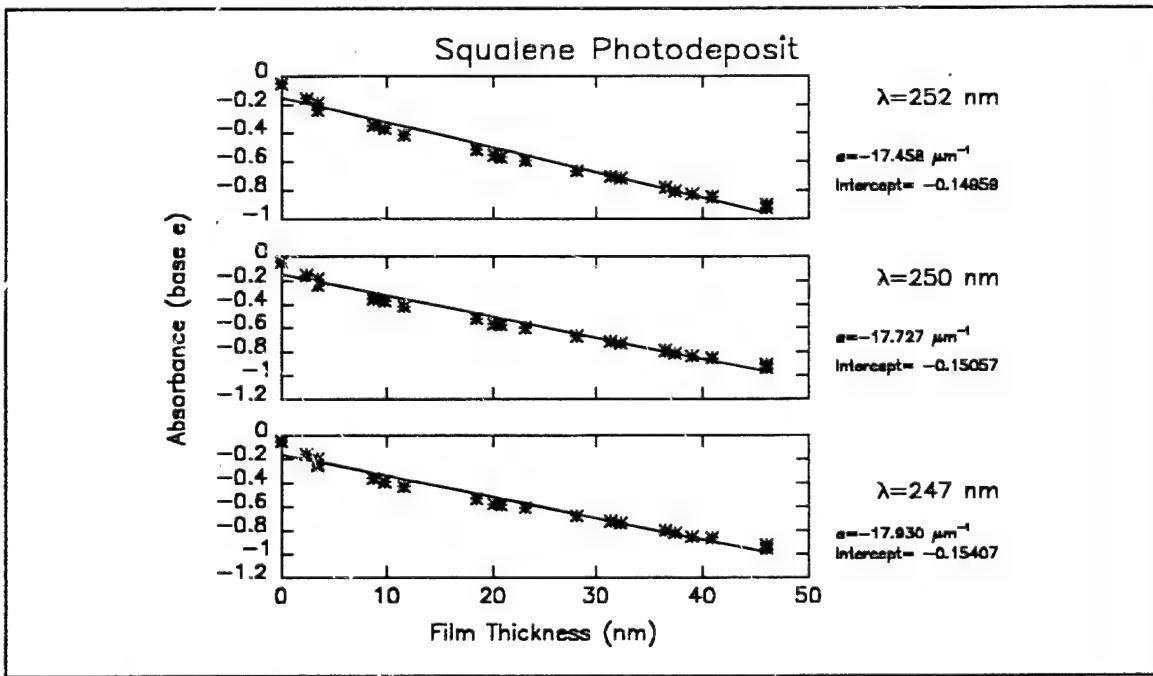


Figure D15t Fits of measured transmission spectra of the Squalene photodepos to the Beer-Lambert absorption law. (Ultraviolet wavelength range)

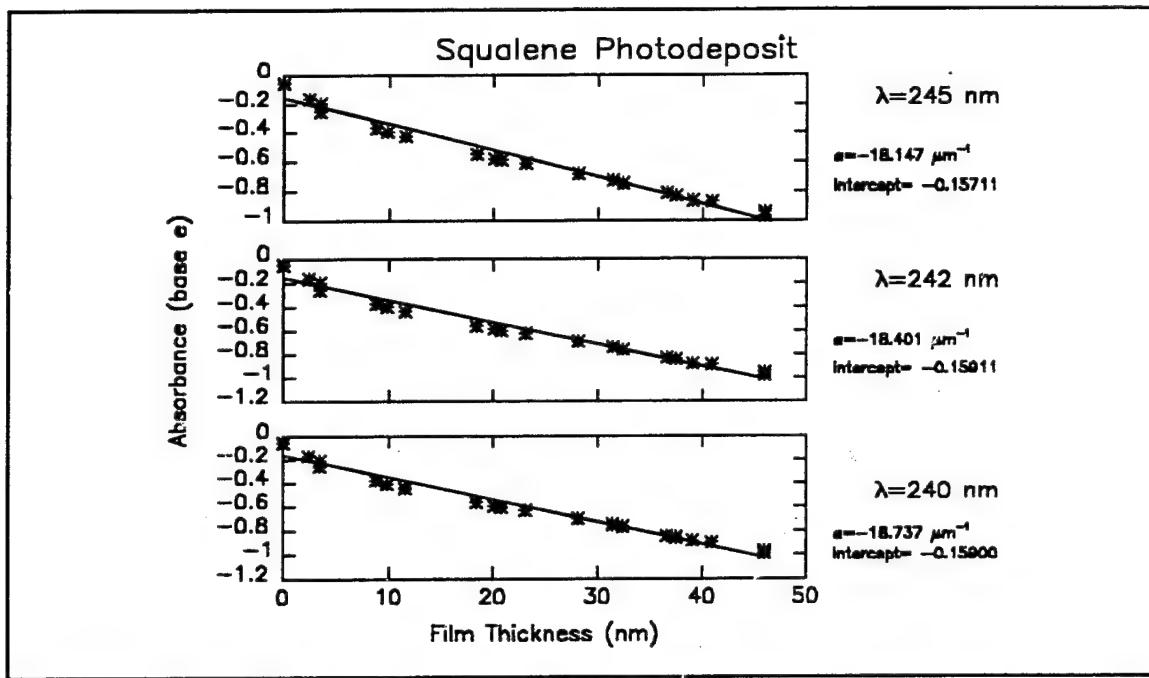


Figure D15u Fits of measured transmission spectra of the Squalene photodeposit to the Beer-Lambert absorption law. (Ultraviolet wavelength range)

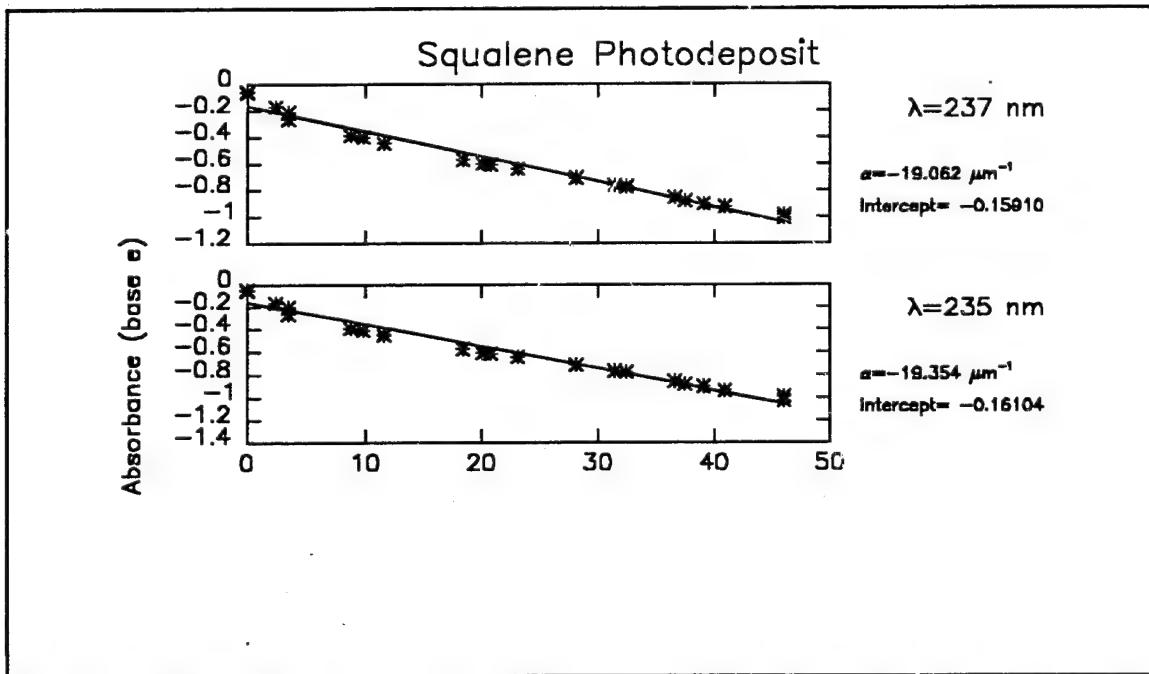


Figure D15v Fits of measured transmission spectra of the Squalene photodeposit to the Beer-Lambert absorption law. (Ultraviolet wavelength range)

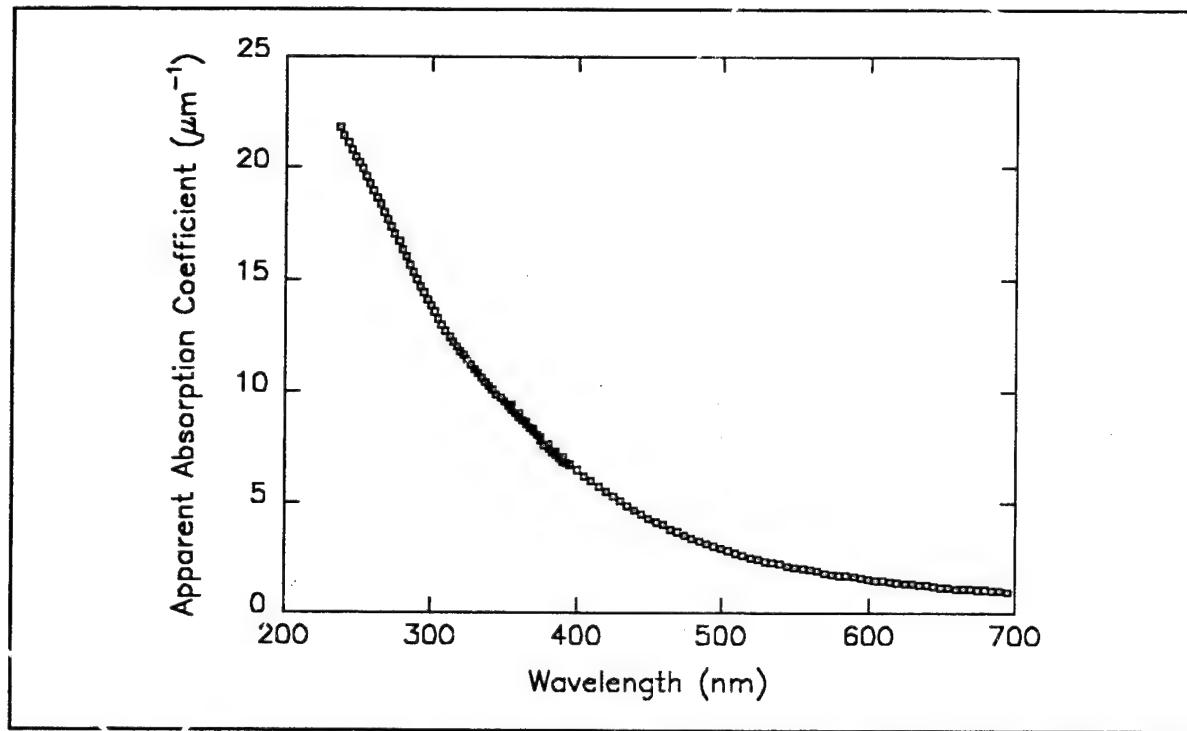


Figure D16. Apparent absorption coefficient obtained from the constrained data fits. Linear plot

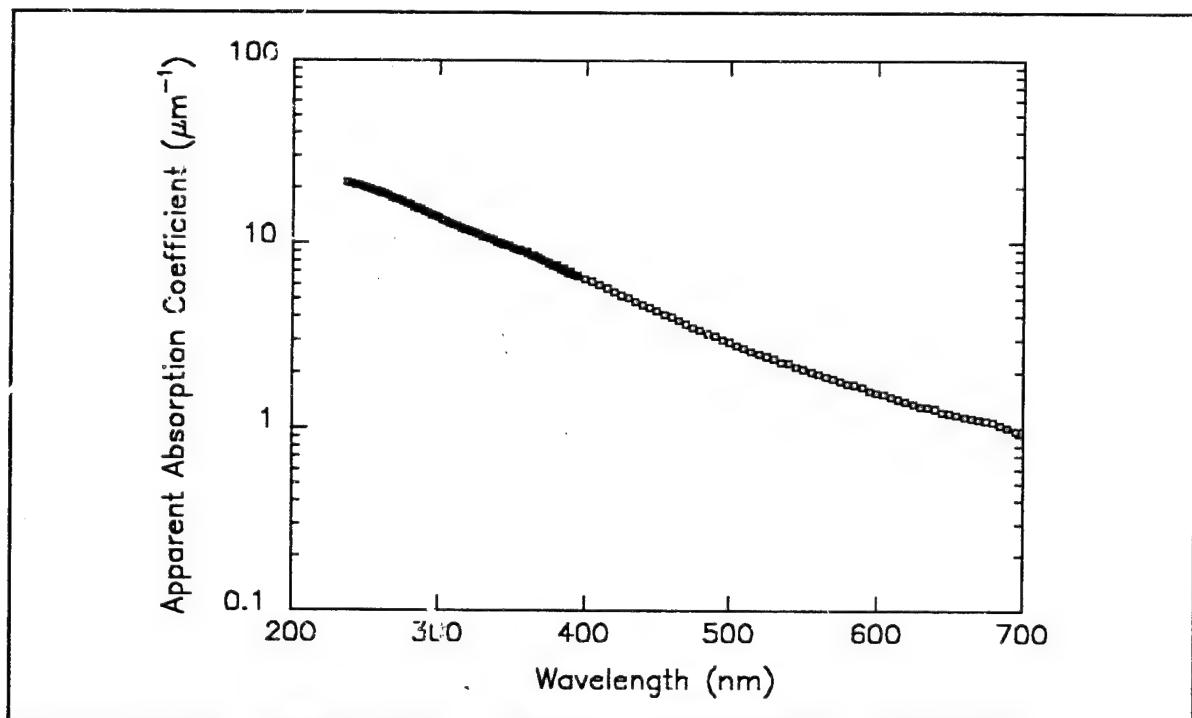


Figure D17. Apparent absorption coefficient obtained from the constrained data fits. Log plot

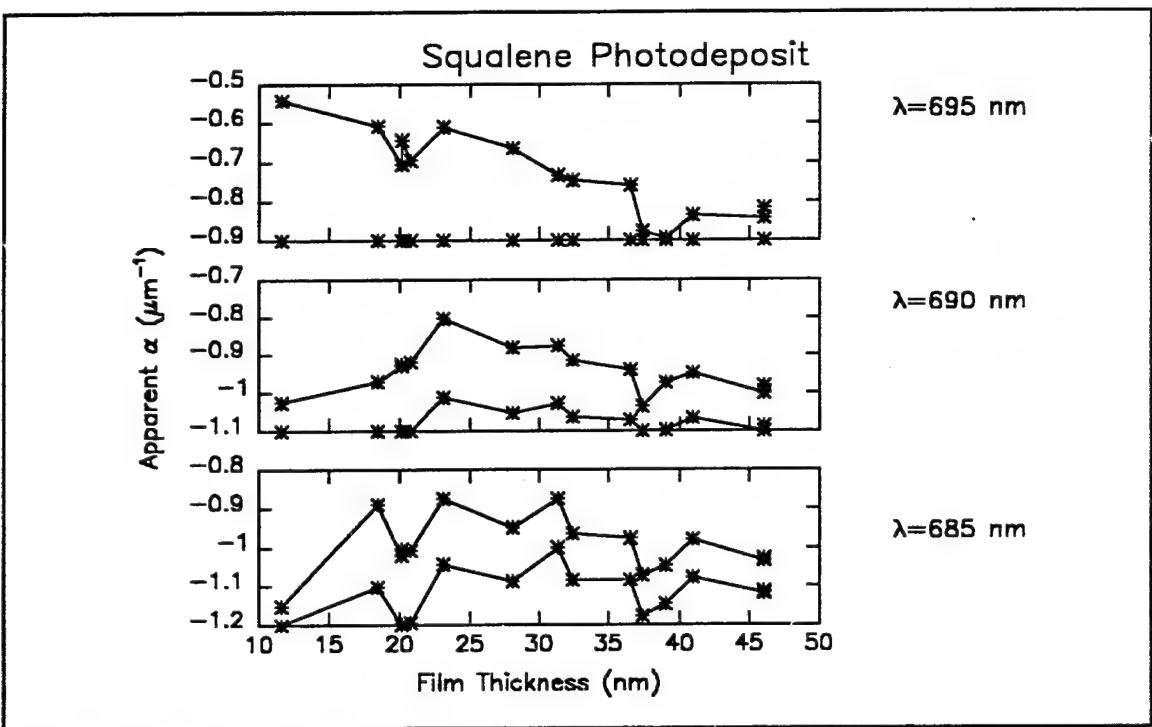


Figure D18a Computed values of α_j for photochemically deposited films of Squalene. (Visible wavelength range)

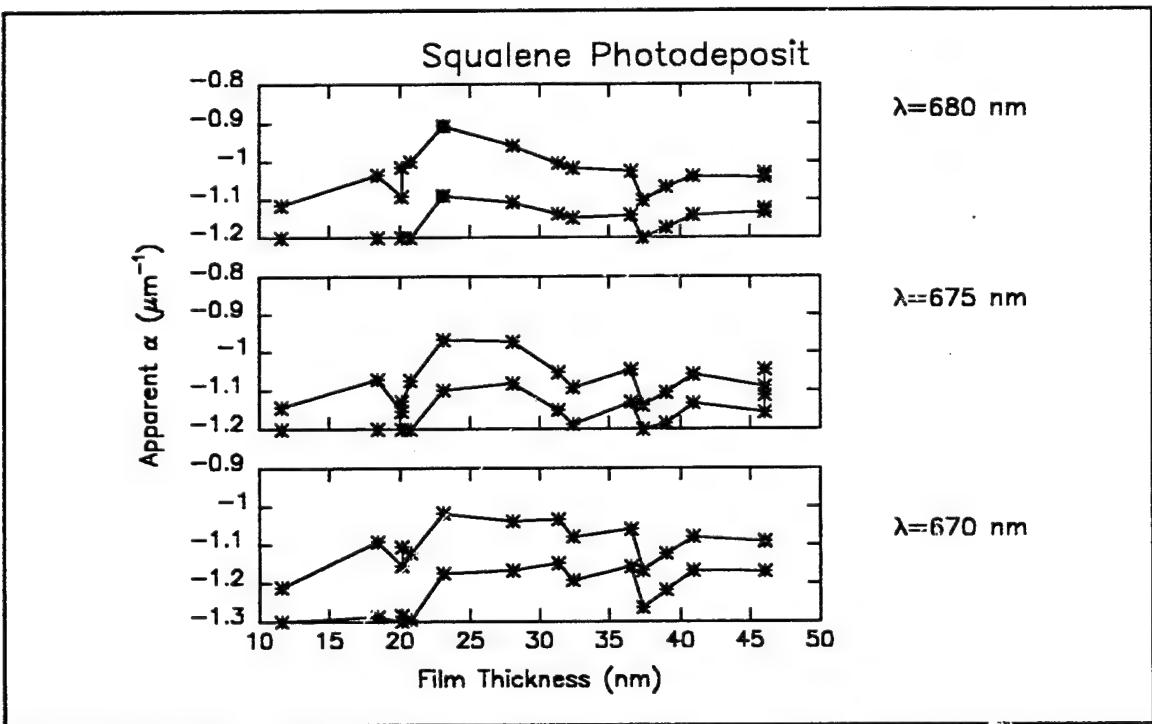


Figure D18b Computed values of α_j for photochemically deposited films of Squalene. (Visible wavelength range)

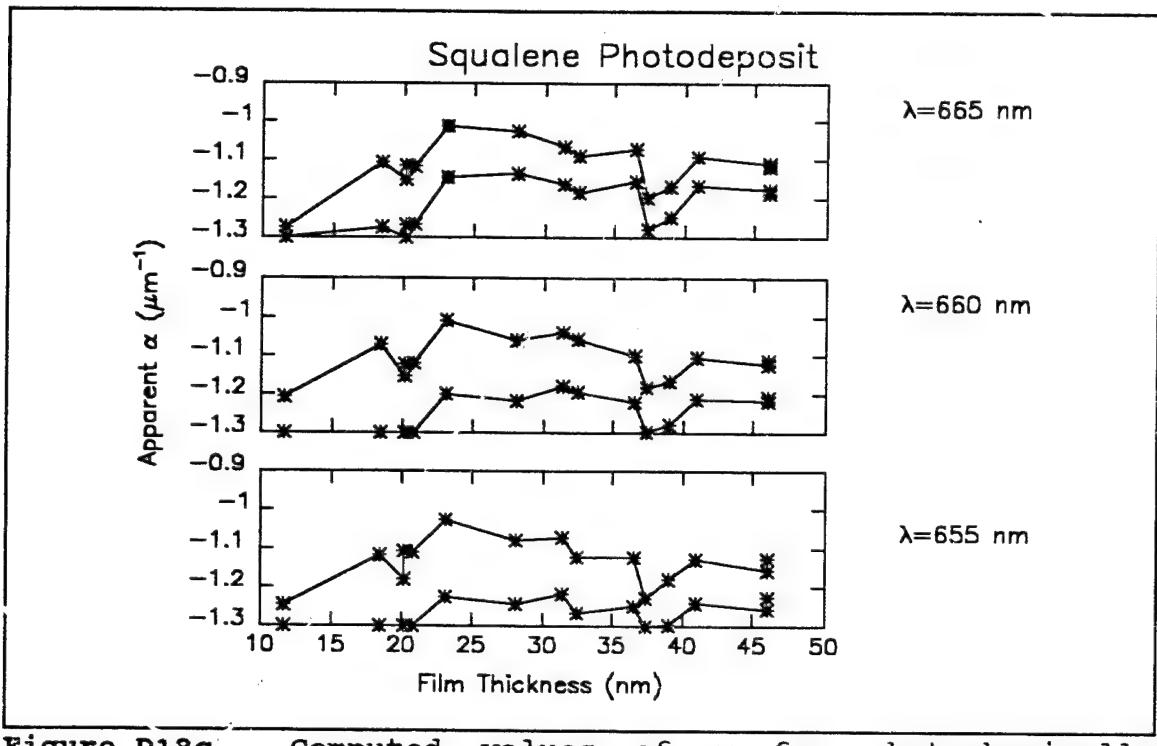


Figure D18c Computed values of α_j for photochemically deposited films of Squalene. (Visible wavelength range)

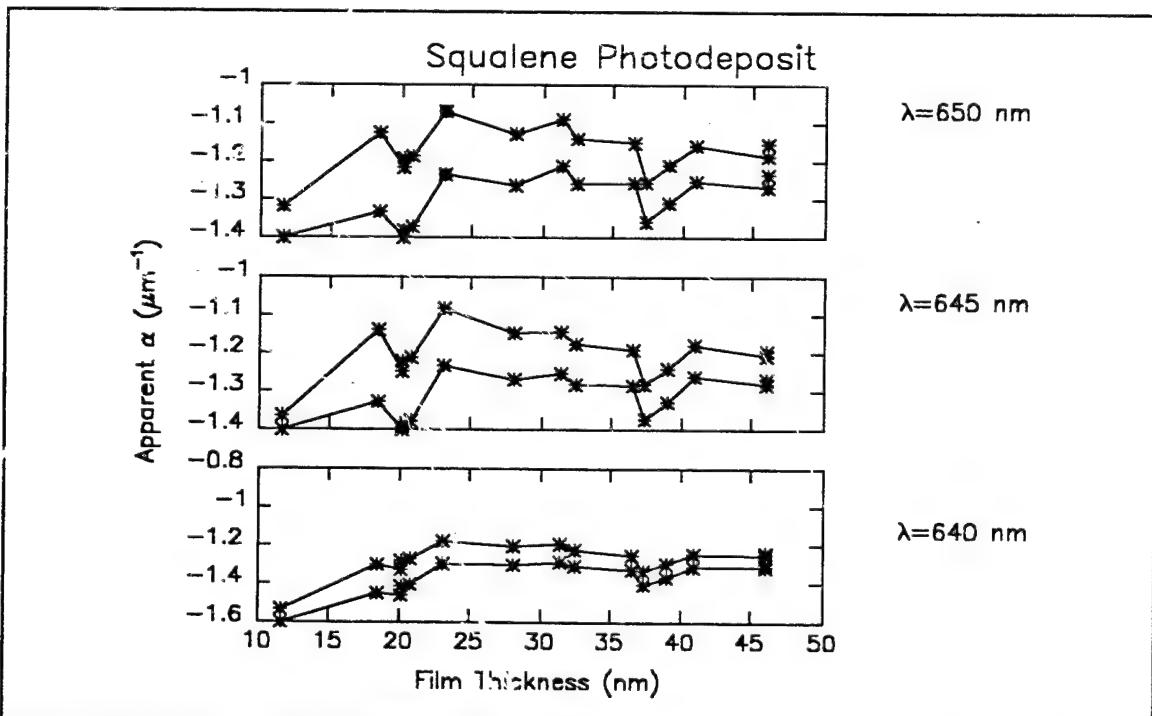


Figure D18d Computed values of α_j for photochemically deposited films of Squalene. (Visible wavelength range)

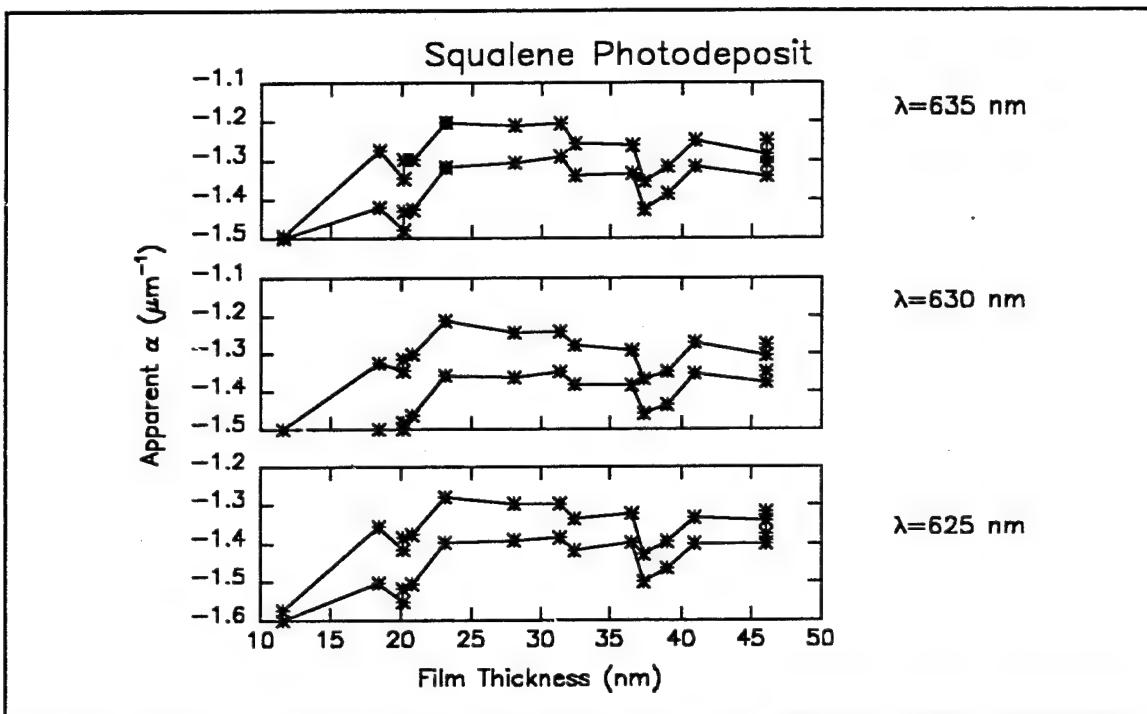


Figure D18e Computed values of α_j for photochemically deposited films of Squalene. (Visible wavelength range)

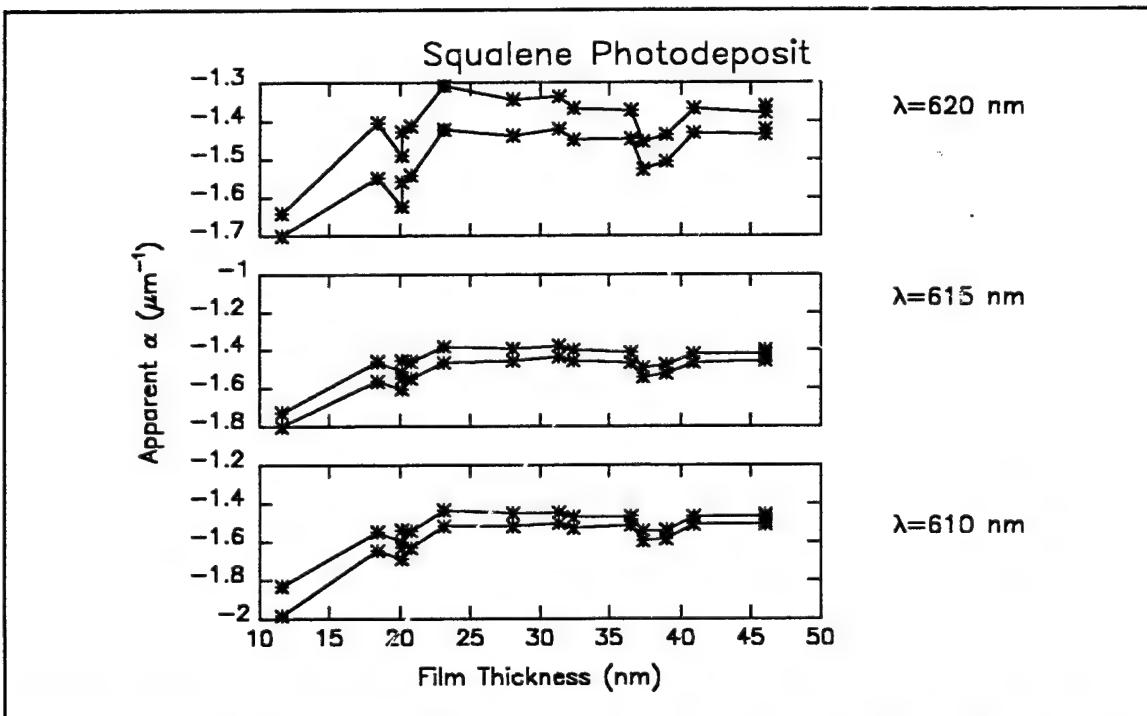


Figure D18f Computed values of α_j for photochemically deposited films of Squalene. (Visible wavelength range)

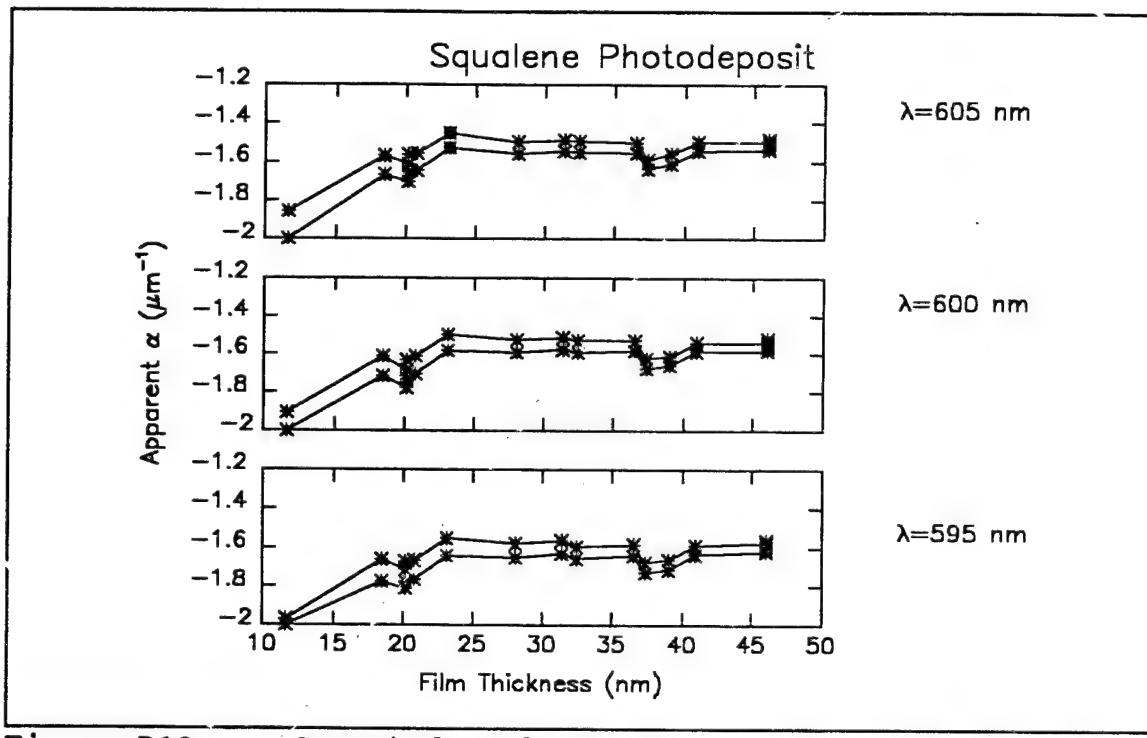


Figure D18g Computed values of α_j for photochemically deposited films of Squalene. (Visible wavelength range)

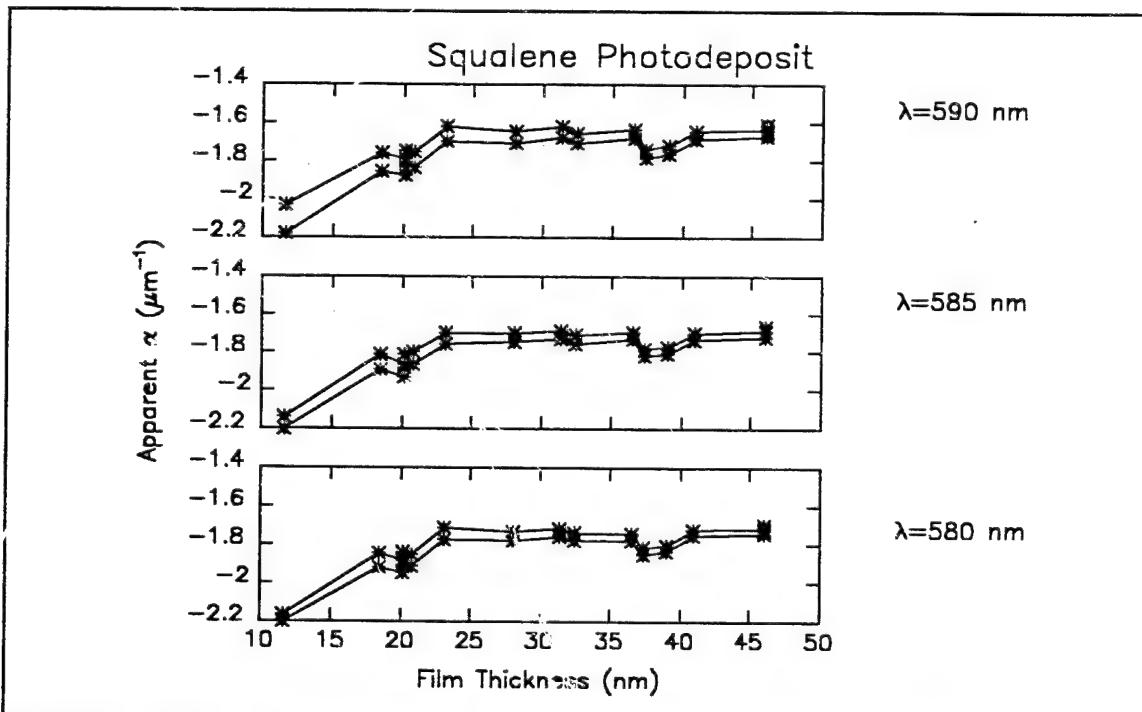


Figure D18h Computed values of α_j for photochemically deposited films of Squalene. (Visible wavelength range)

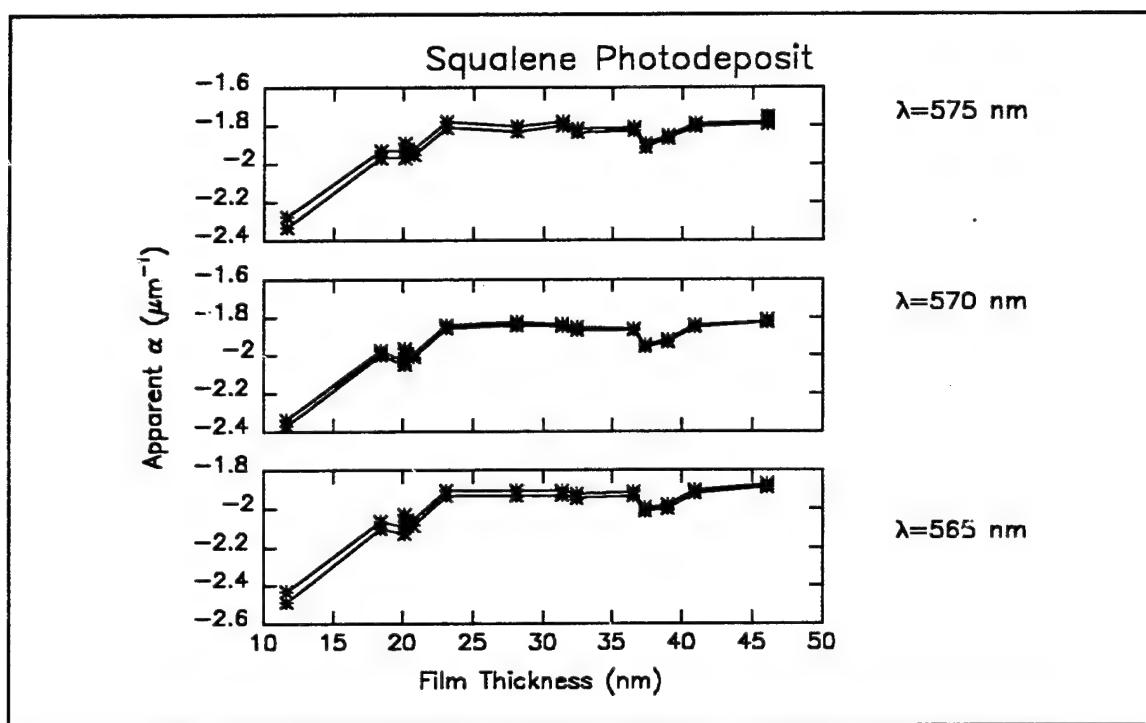


Figure D18i Computed values of α_j for photochemically deposited films of Squalene. (Visible wavelength range)

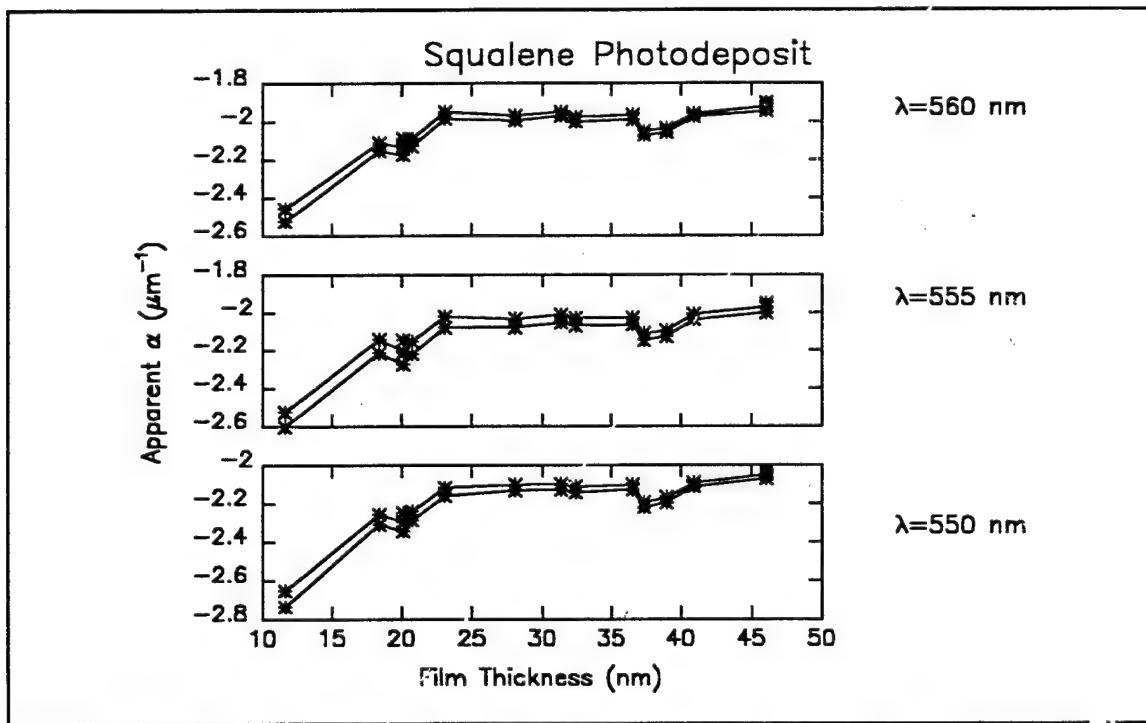


Figure D18j Computed values of α_j for photochemically deposited films of Squalene. (Visible wavelength range)

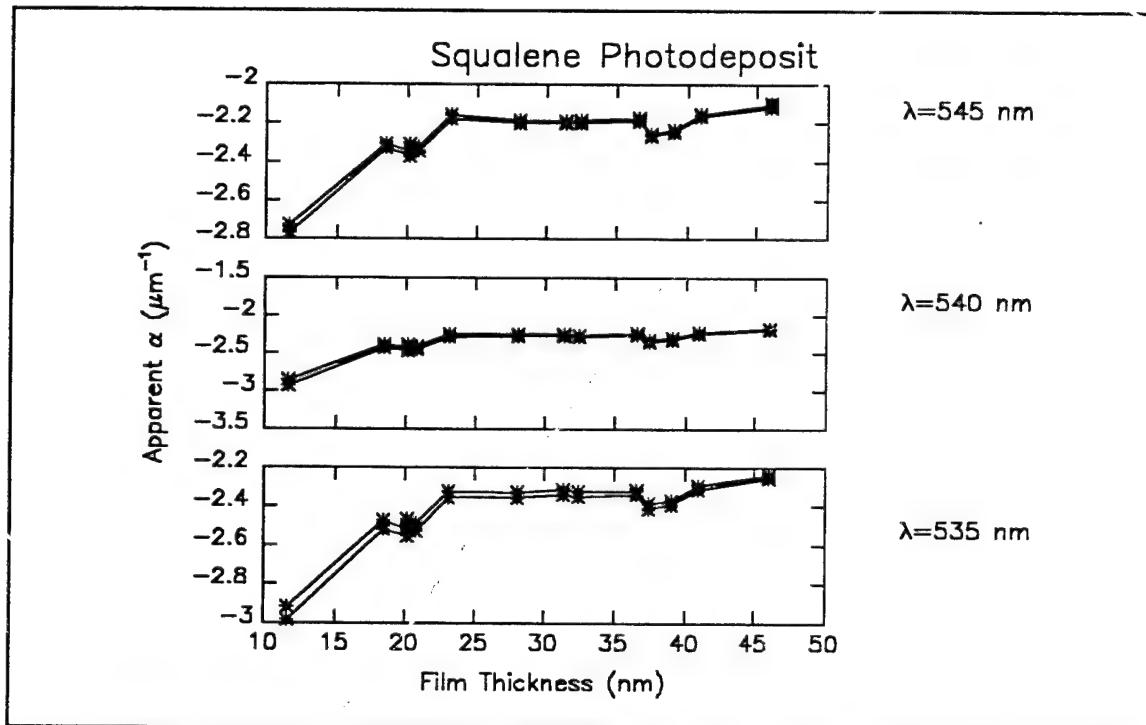


Figure D18k Computed values of α_j for photochemically deposited films of Squalene. (Visible wavelength range)

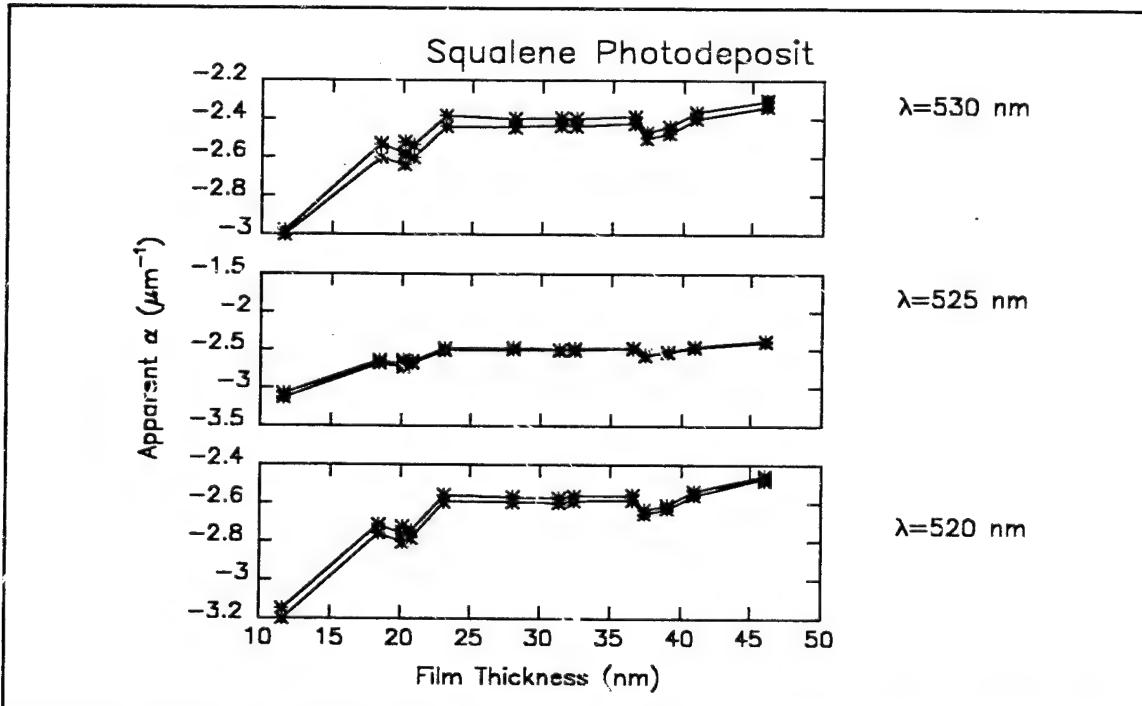


Figure D18l Computed values of α_j for photochemically deposited films of Squalene. (Visible wavelength range)

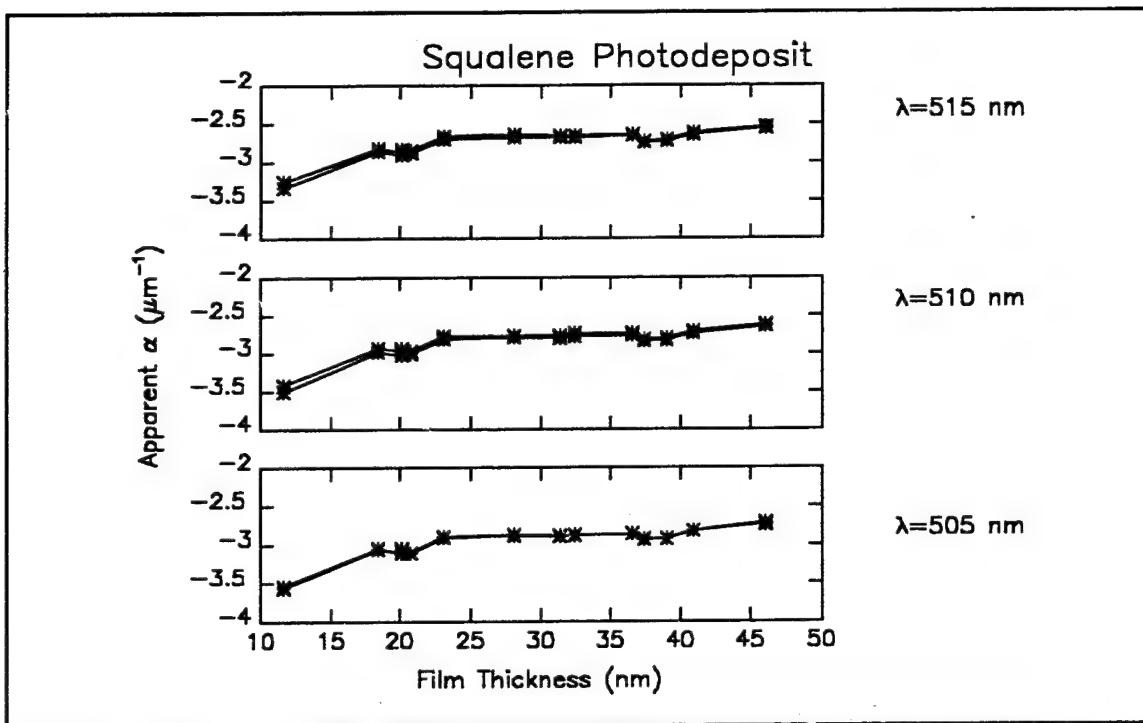


Figure D18m Computed values of α_j for photochemically deposited films of Squalene. (Visible wavelength range)

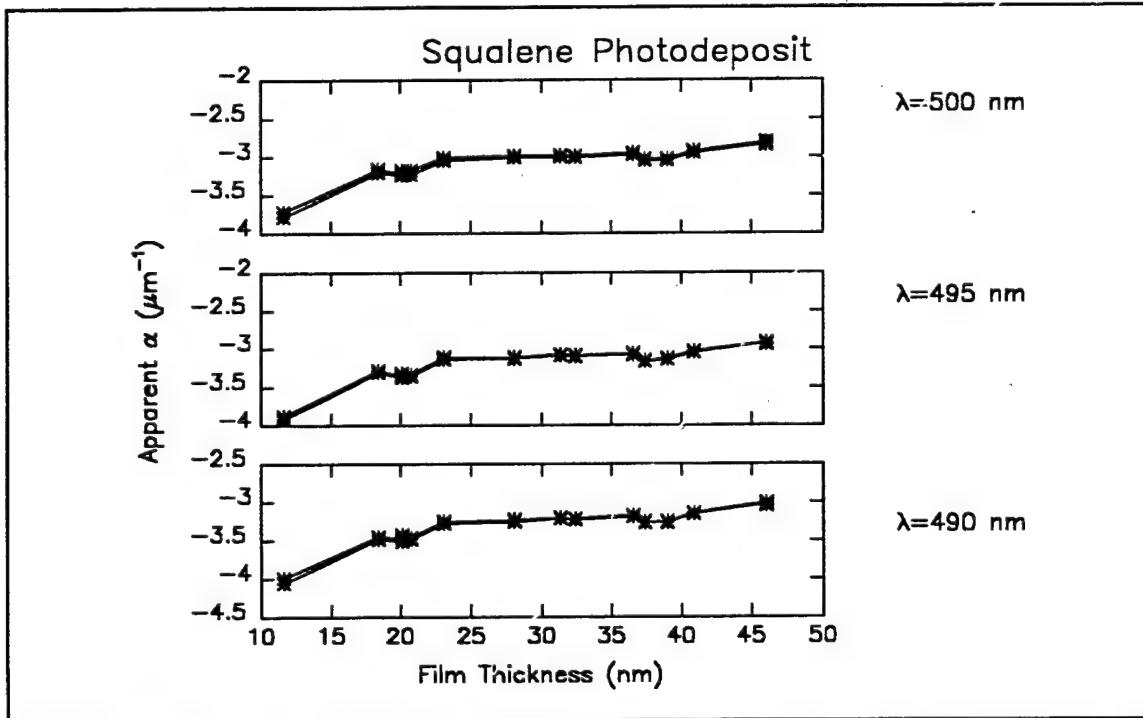


Figure D18n Computed values of α_j for photochemically deposited films of Squalene. (Visible wavelength range)

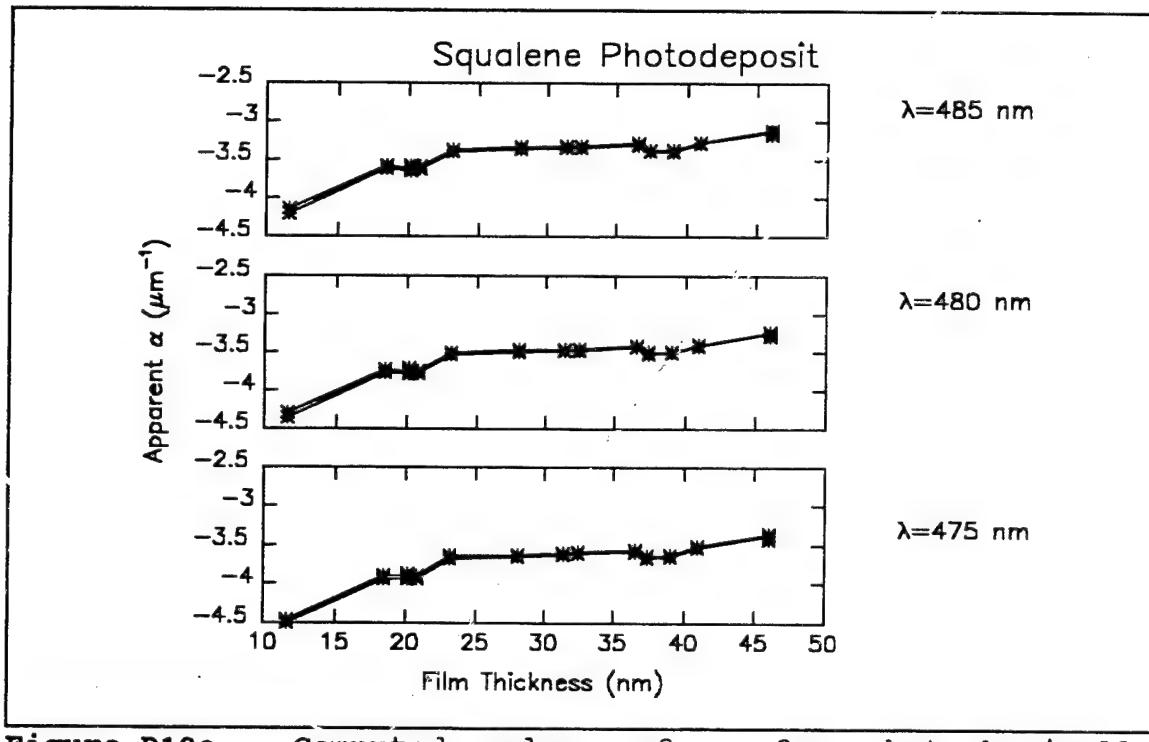


Figure D18o Computed values of α_j for photochemically deposited films of Squalene. (Visible wavelength range)

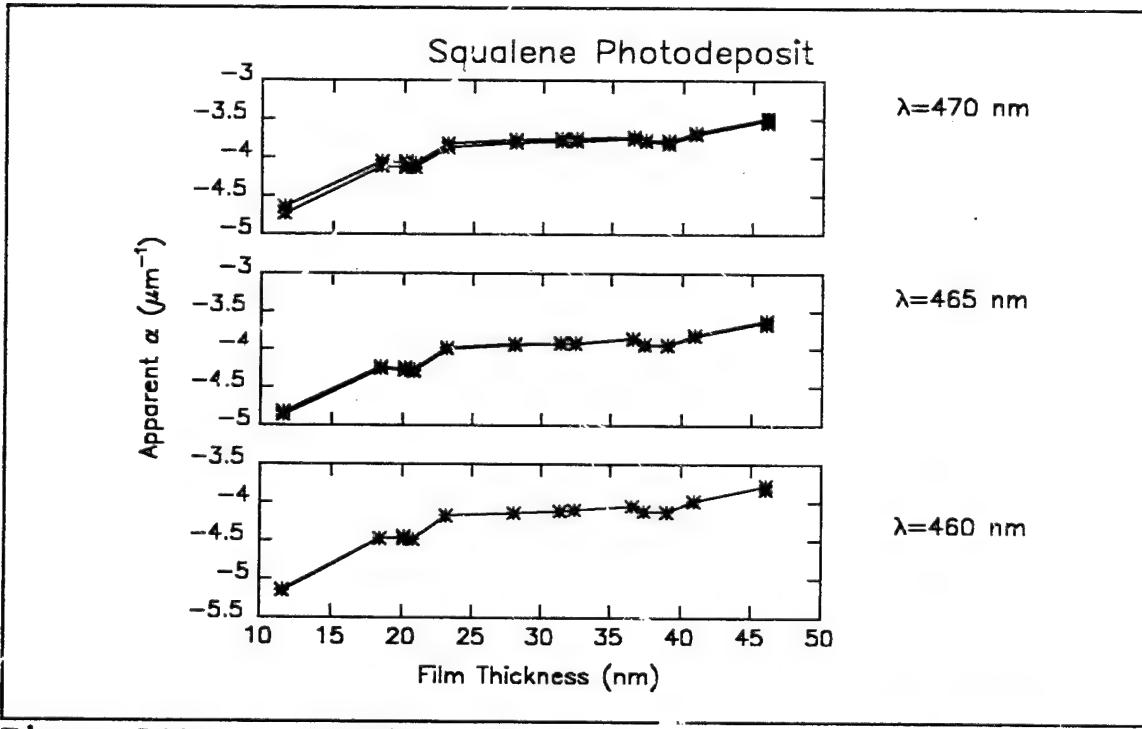


Figure D18p Computed values of α_j for photochemically deposited films of Squalene. (Visible wavelength range)

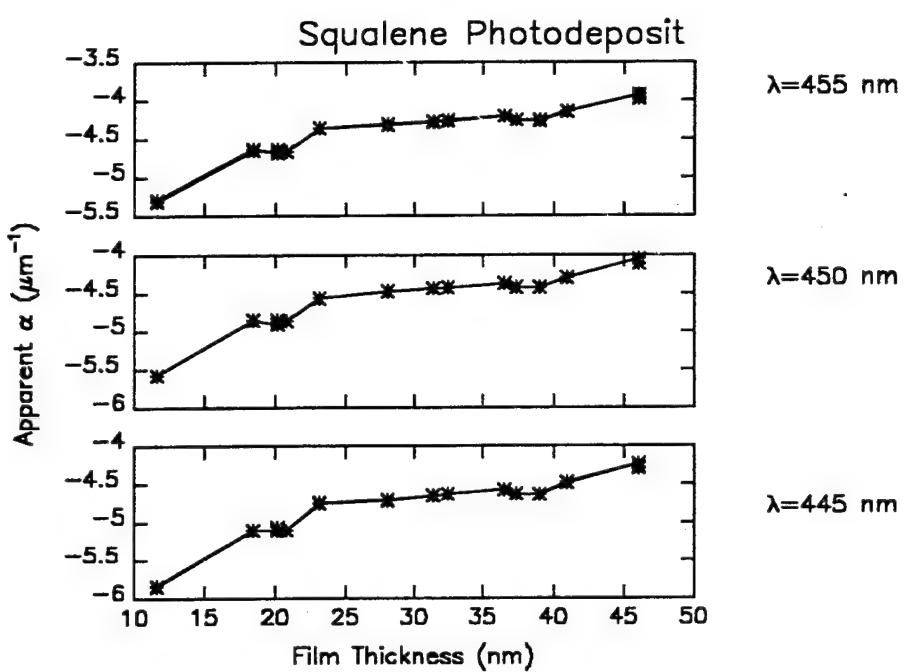


Figure D18q Computed values of α_j for photochemically deposited films of Squalene. (Visible wavelength range)

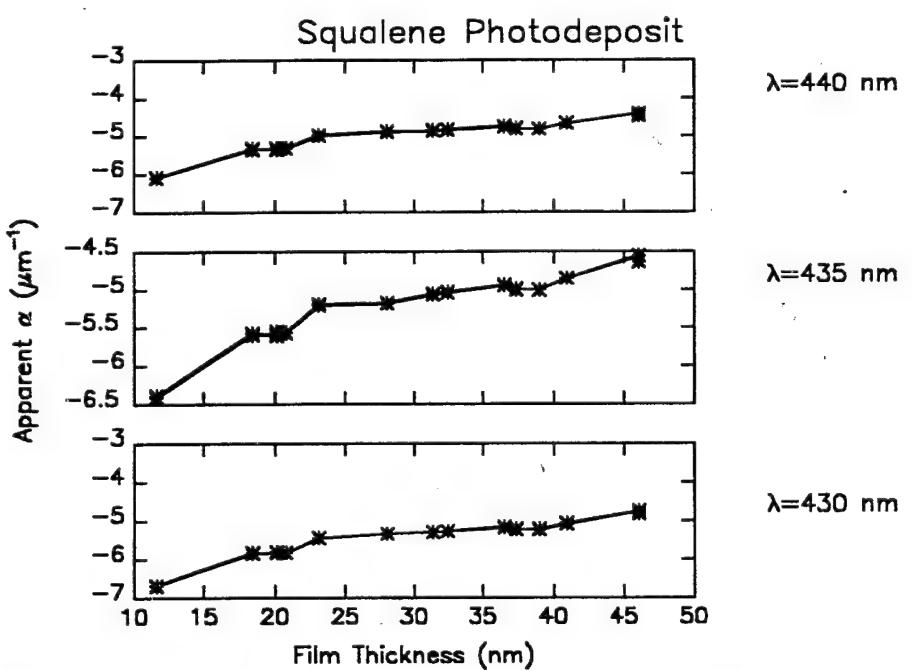


Figure D18r Computed values of α_j for photochemically deposited films of Squalene. (Visible wavelength range)

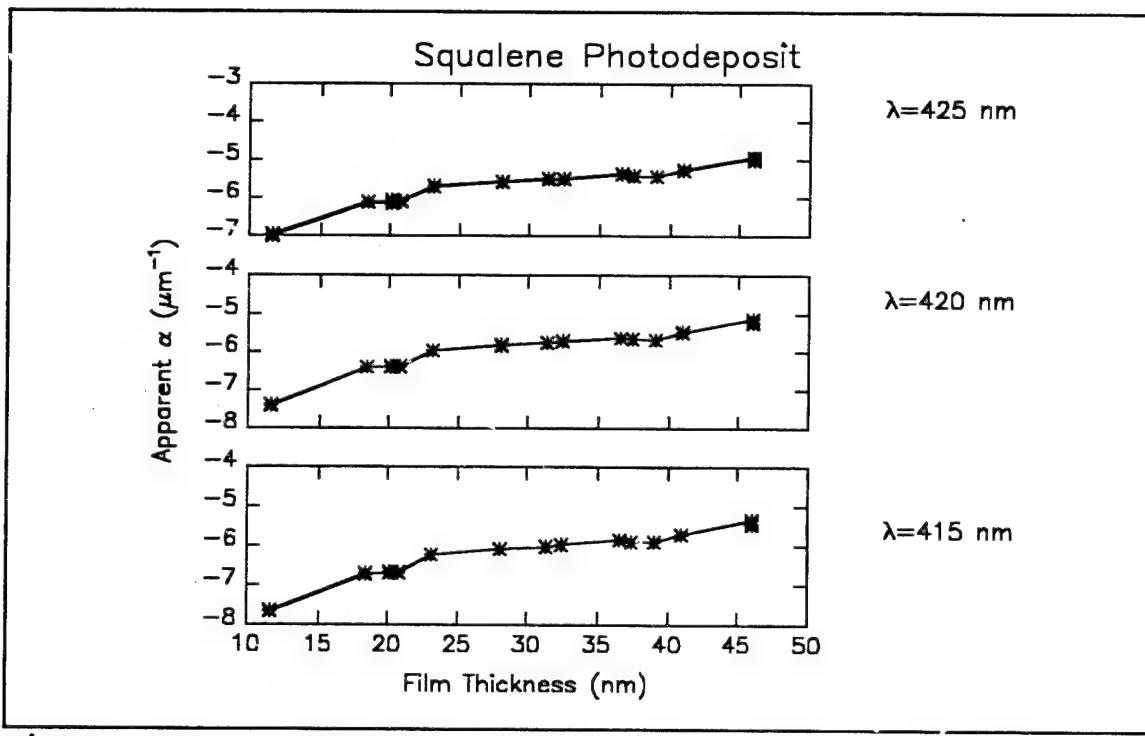


Figure D18s Computed values of α_j for photochemically deposited films of Squalene. (Visible wavelength range)

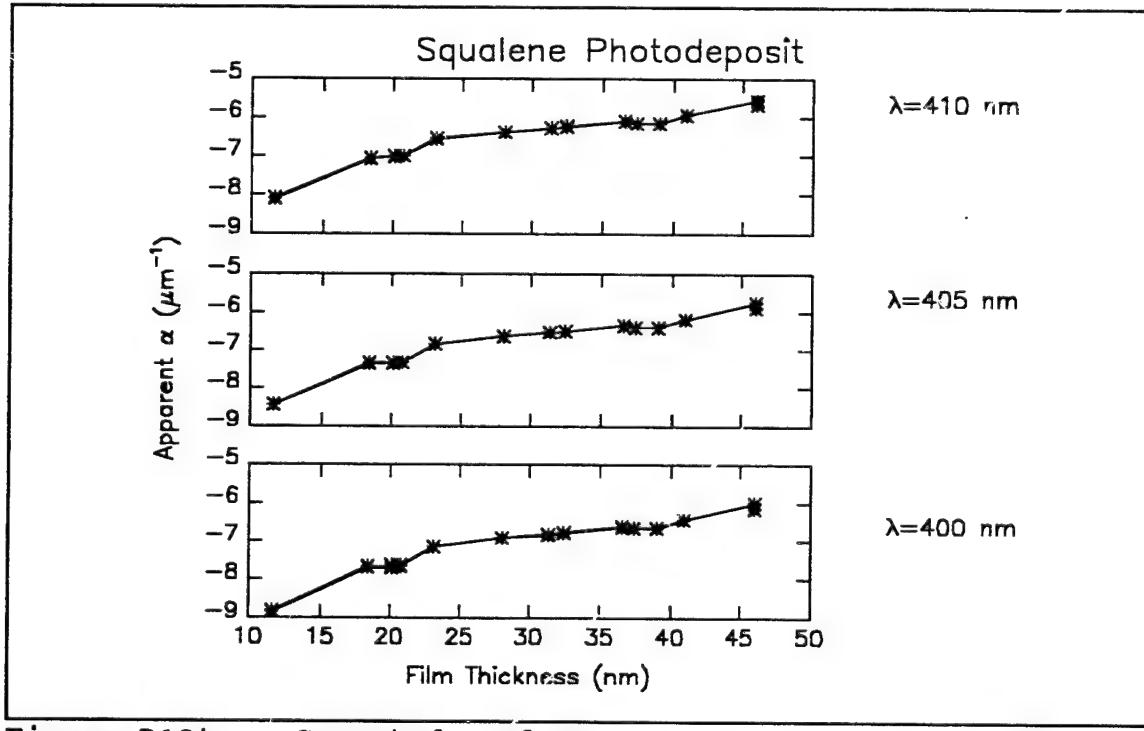


Figure D18t Computed values of α_j for photochemically deposited films of Squalene. (Visible wavelength range)

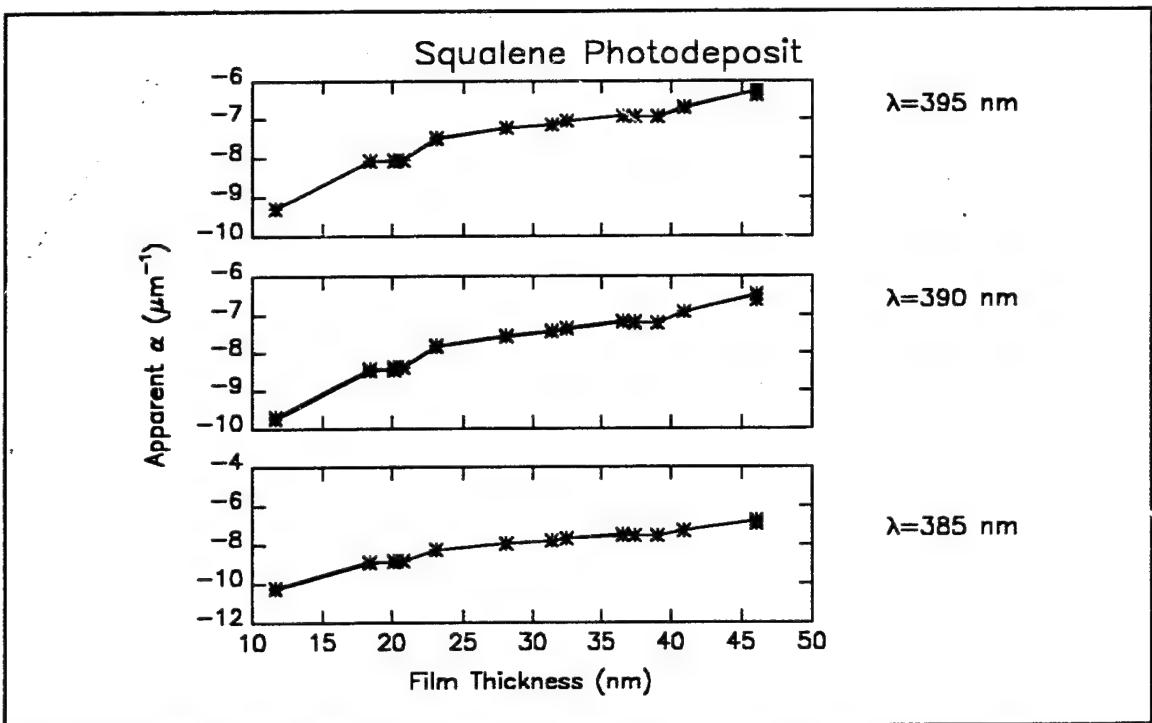


Figure D18u Computed values of α_j for photochemically deposited films of Squalene. (Visible wavelength range)

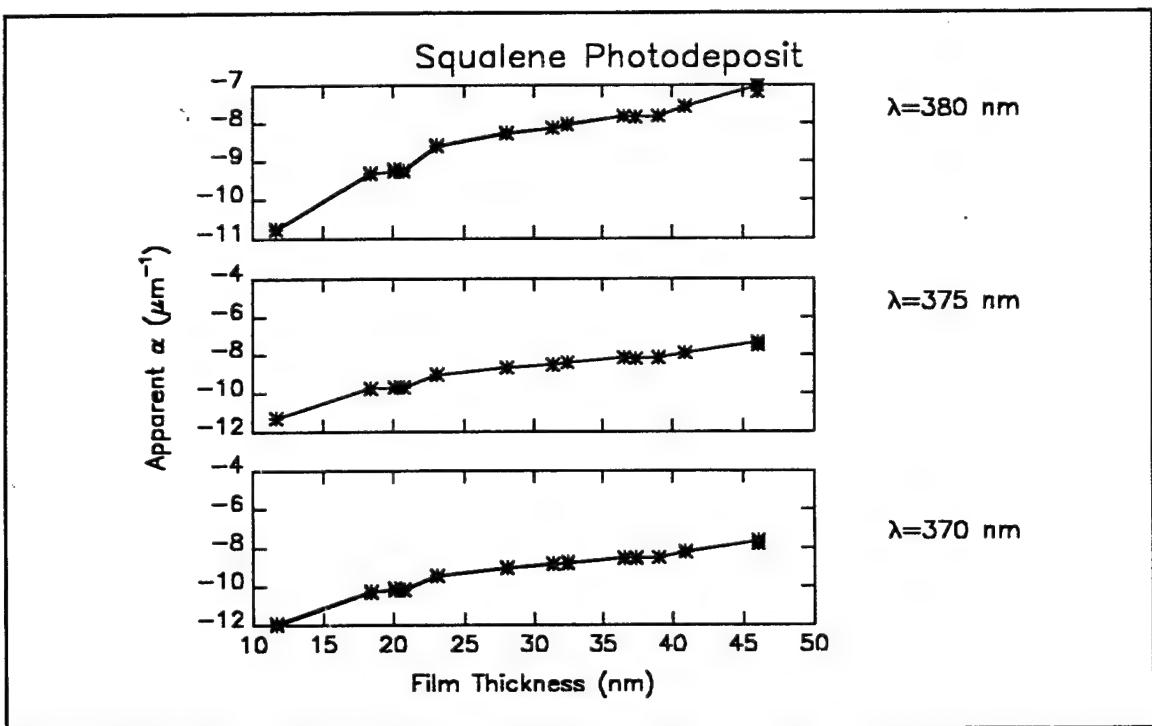


Figure D18v Computed values of α_j for photochemically deposited films of Squalene. (Visible wavelength range)

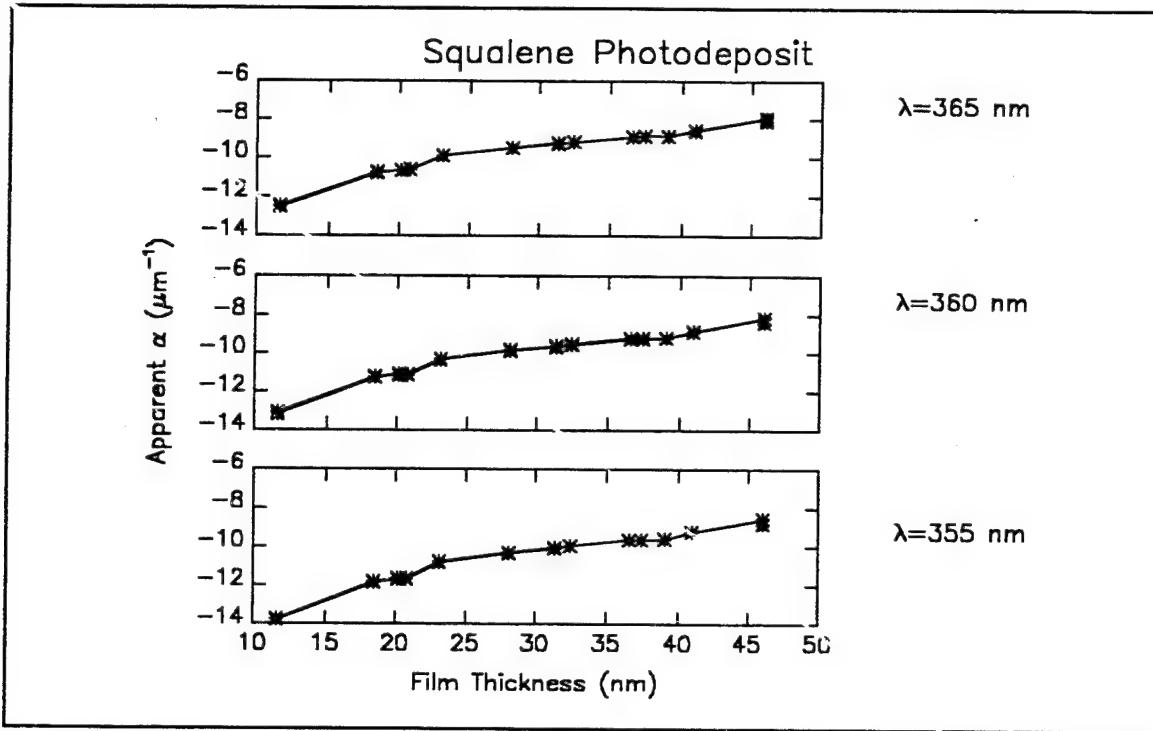


Figure D18w Computed values of α_j for photochemically deposited films of Squalene. (Visible wavelength range)

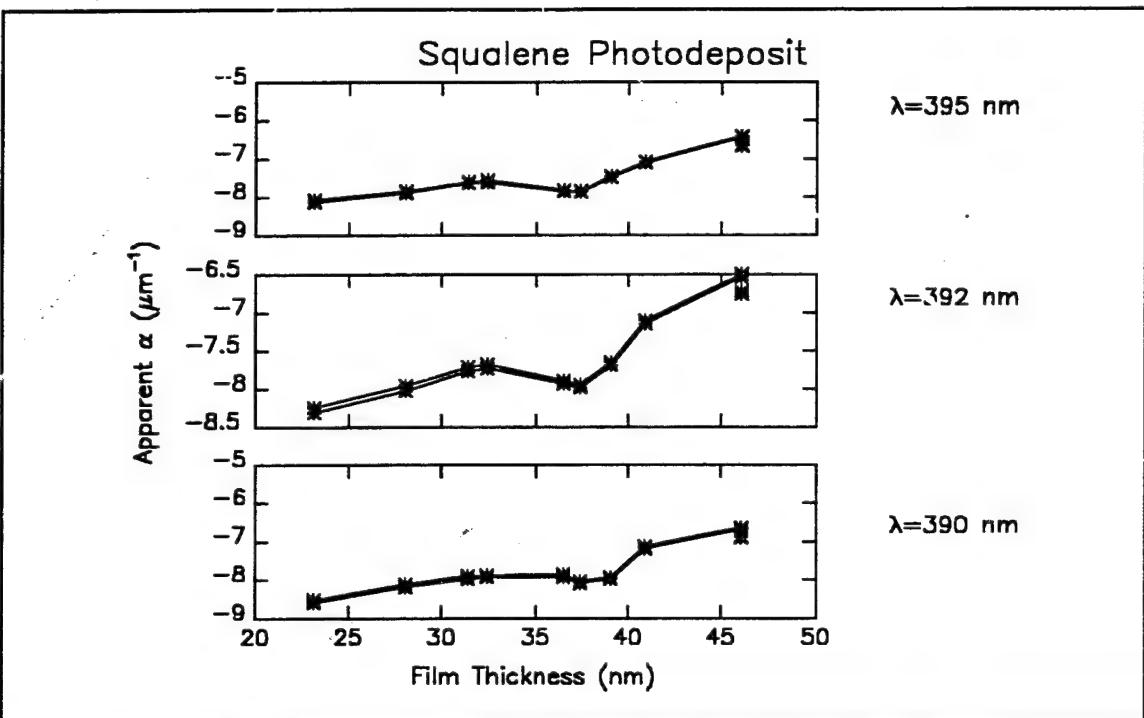


Figure D19a Computed values of α_i for photochemically deposited films of Squalene. (Ultraviolet wavelenght range)

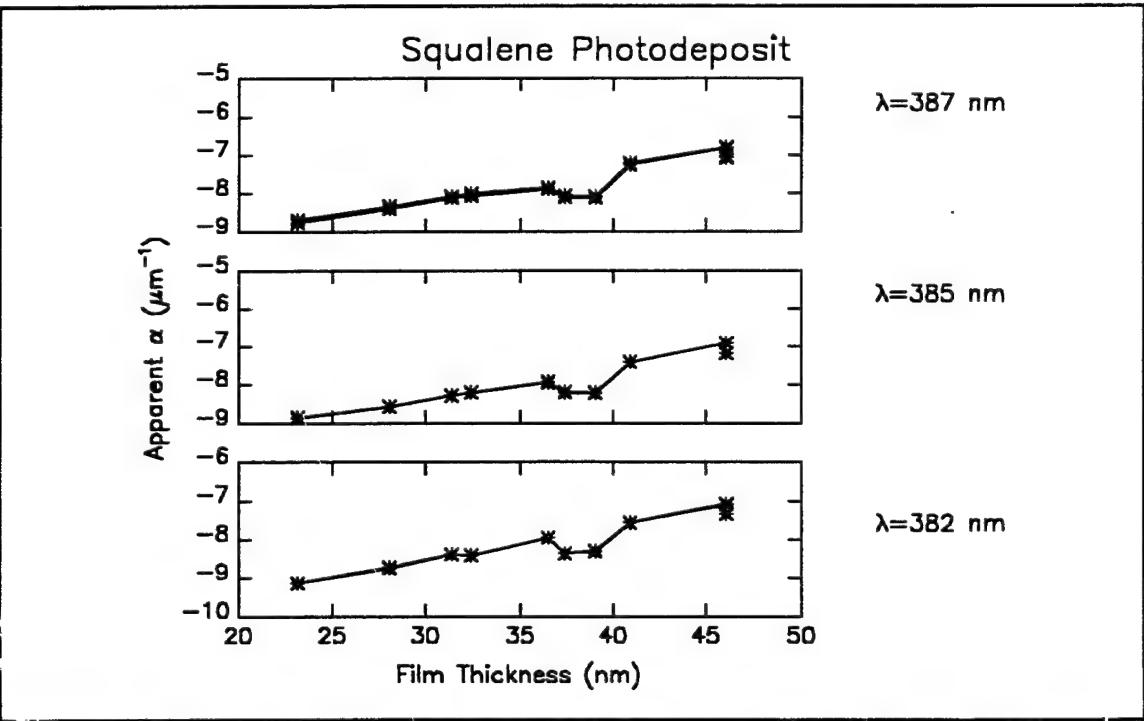


Figure D19b Computed values of α_i for photochemically deposited films of Squalene. (Ultraviolet wavelenght range)

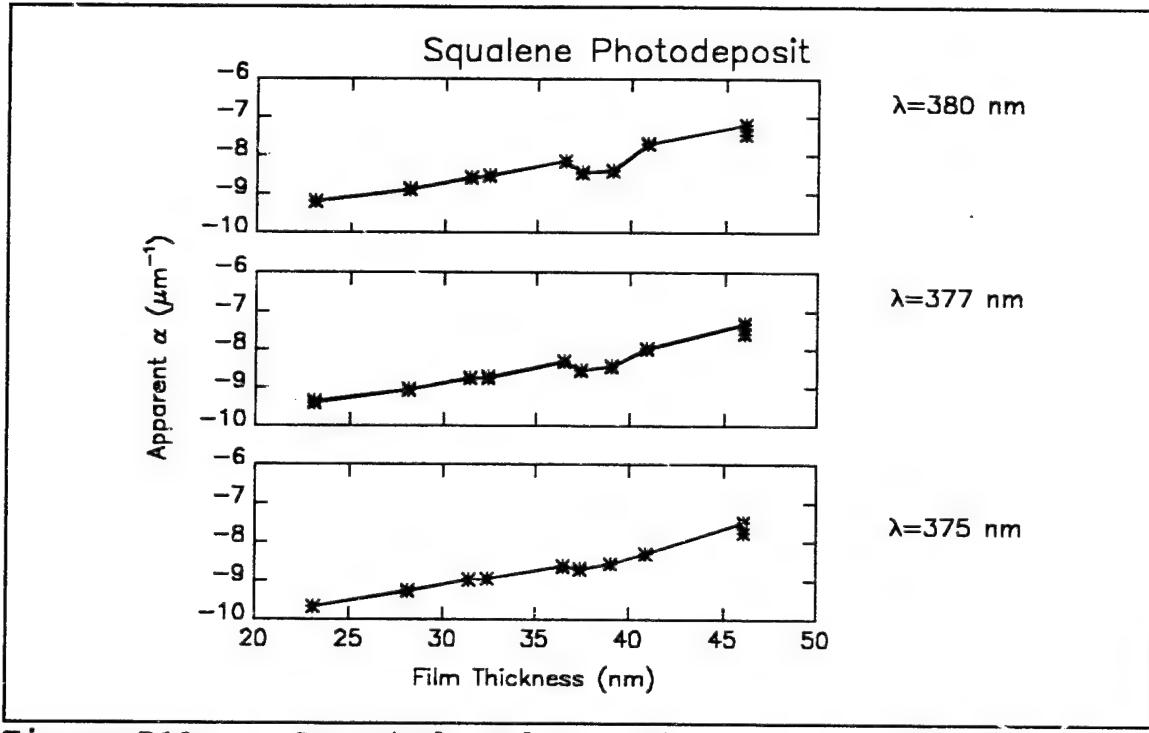


Figure D19c Computed values of α_j for photochemically deposited films of Squalene. (Ultraviolet wavelenght range)

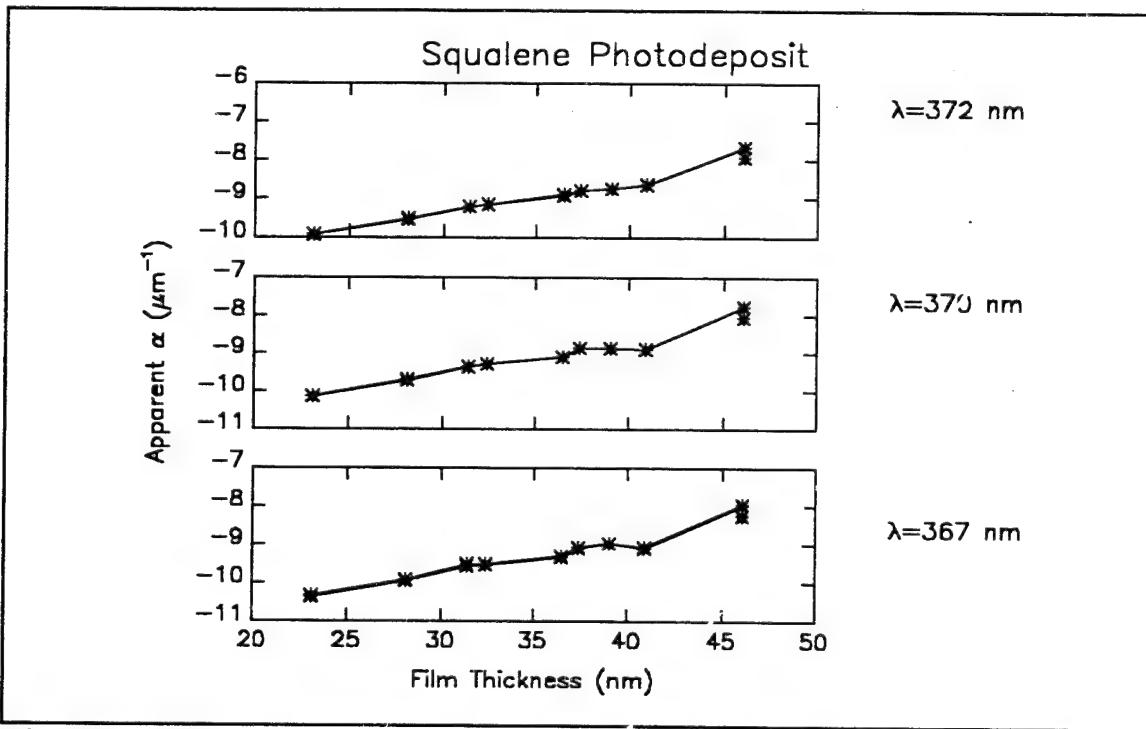


Figure D19d Computed values of α_j for photochemically deposited films of Squalene. (Ultraviolet wavelenght range)

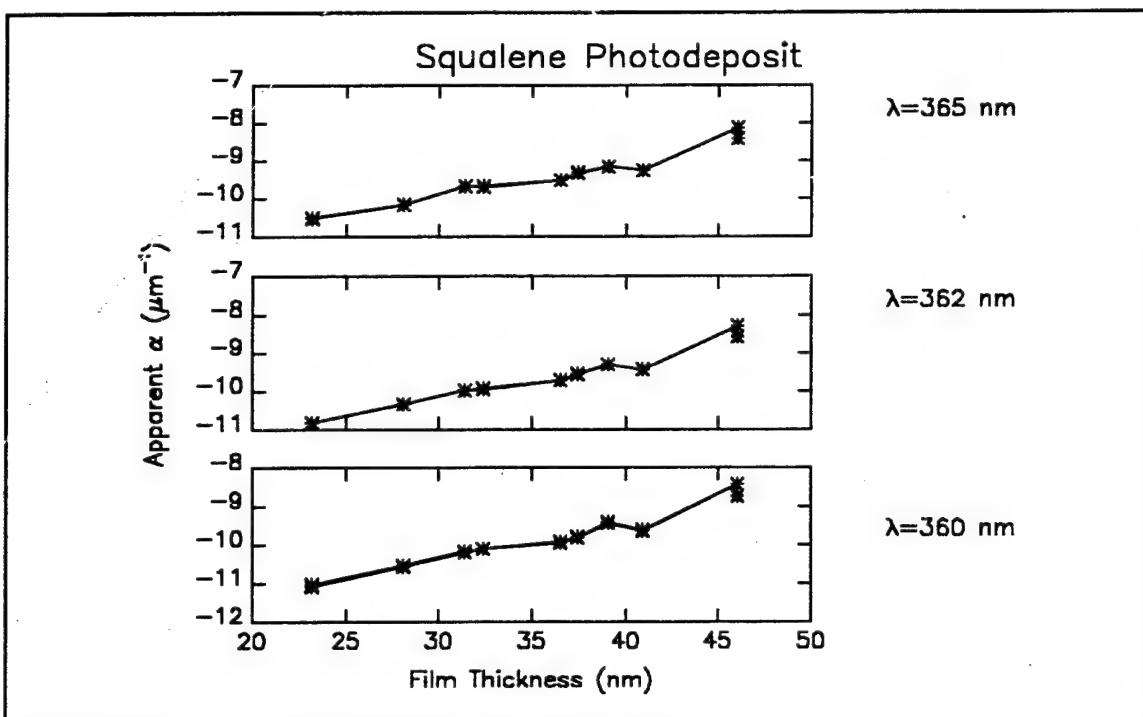


Figure D19e Computed values of α_i for photochemically deposited films of Squalene. (Ultraviolet wavelenght range)

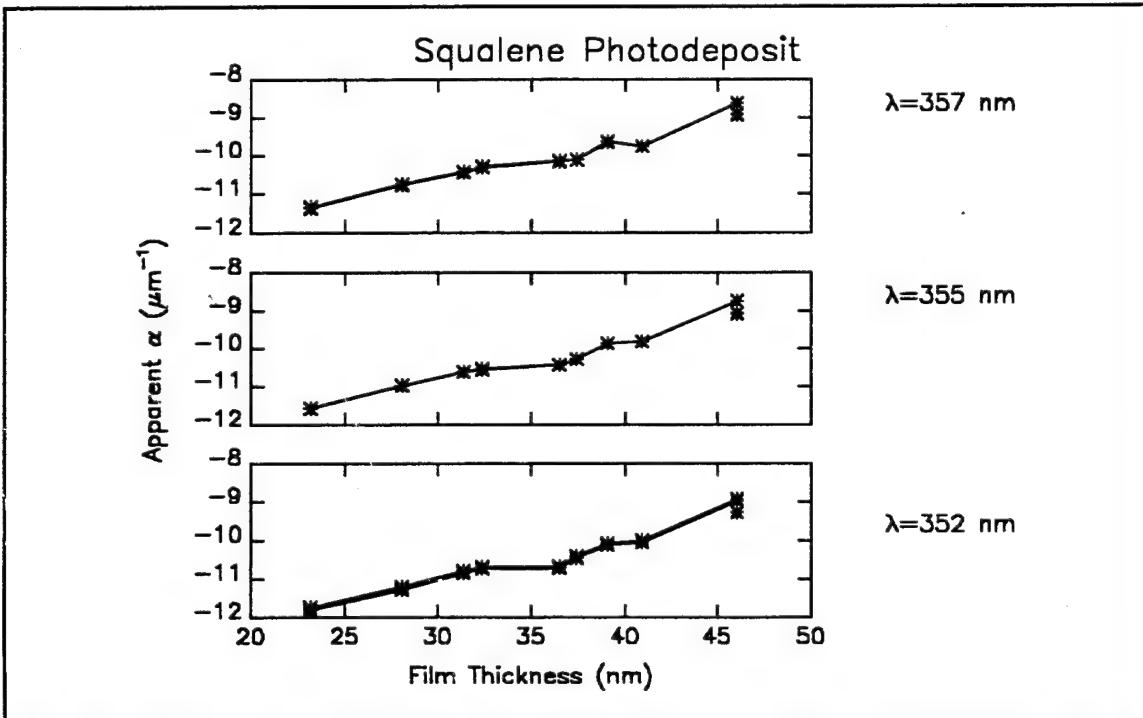


Figure D19f Computed values of α_i for photochemically deposited films of Squalene. (Ultraviolet wavelenght range)

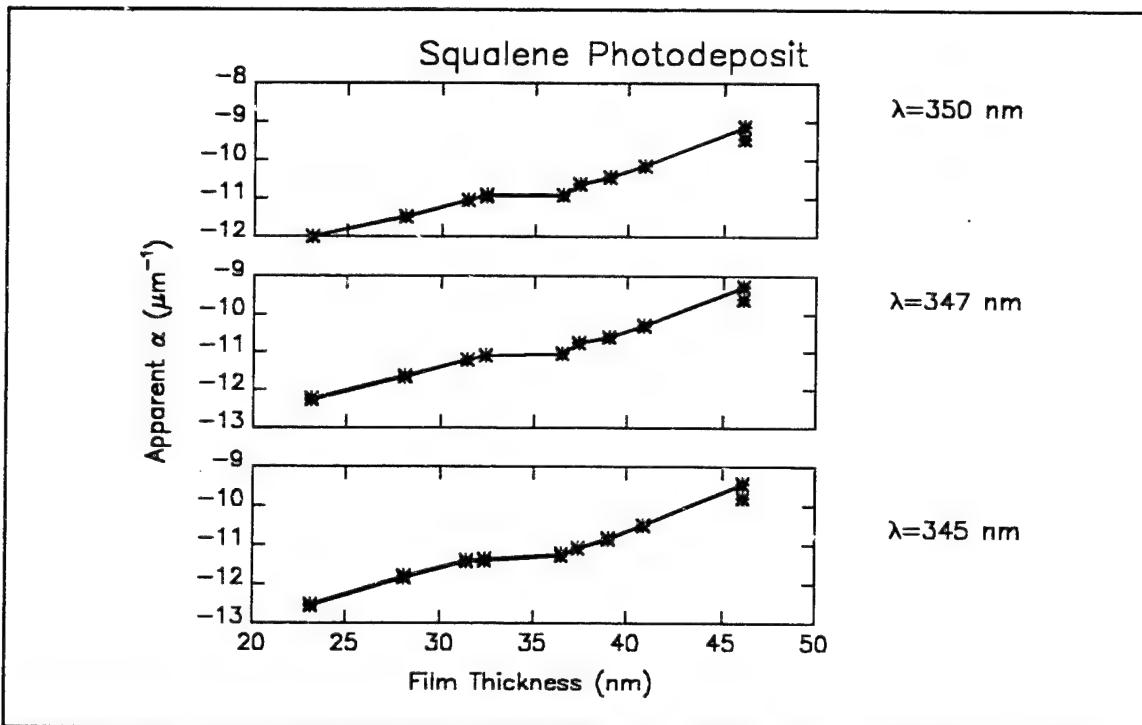


Figure D19g Computed values of α_j for photochemically deposited films of Squalene. (Ultraviolet wavelenght range)

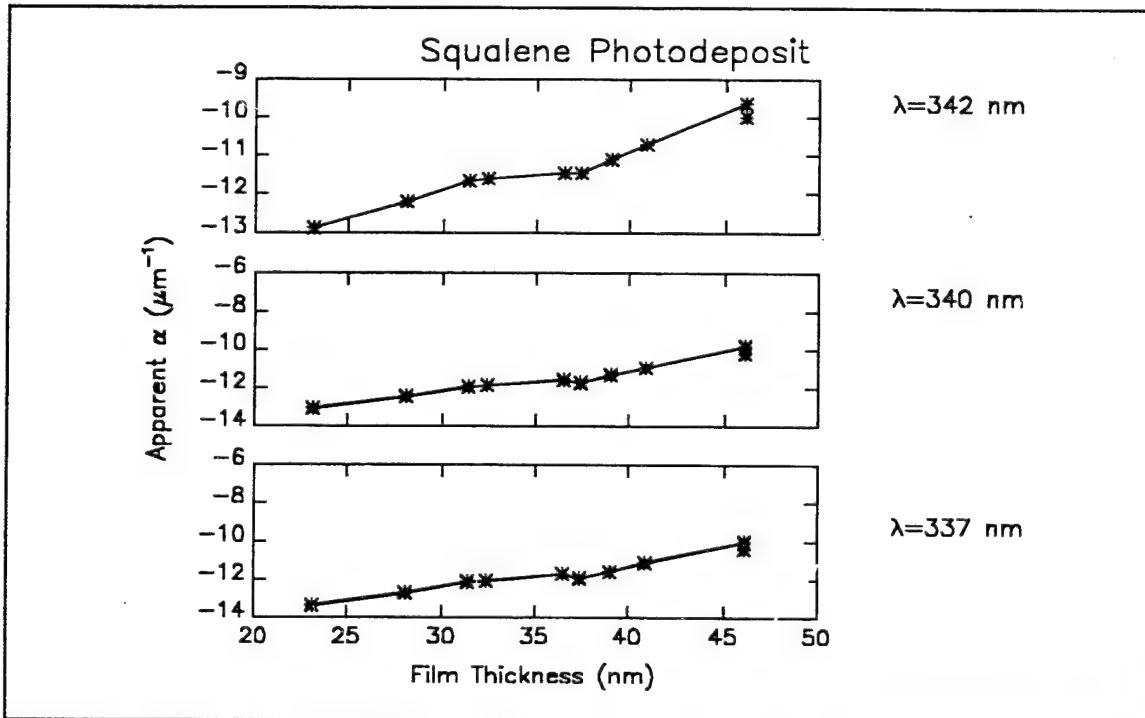


Figure D19h Computed values of α_j for photochemically deposited films of Squalene. (Ultraviolet wavelenght range)

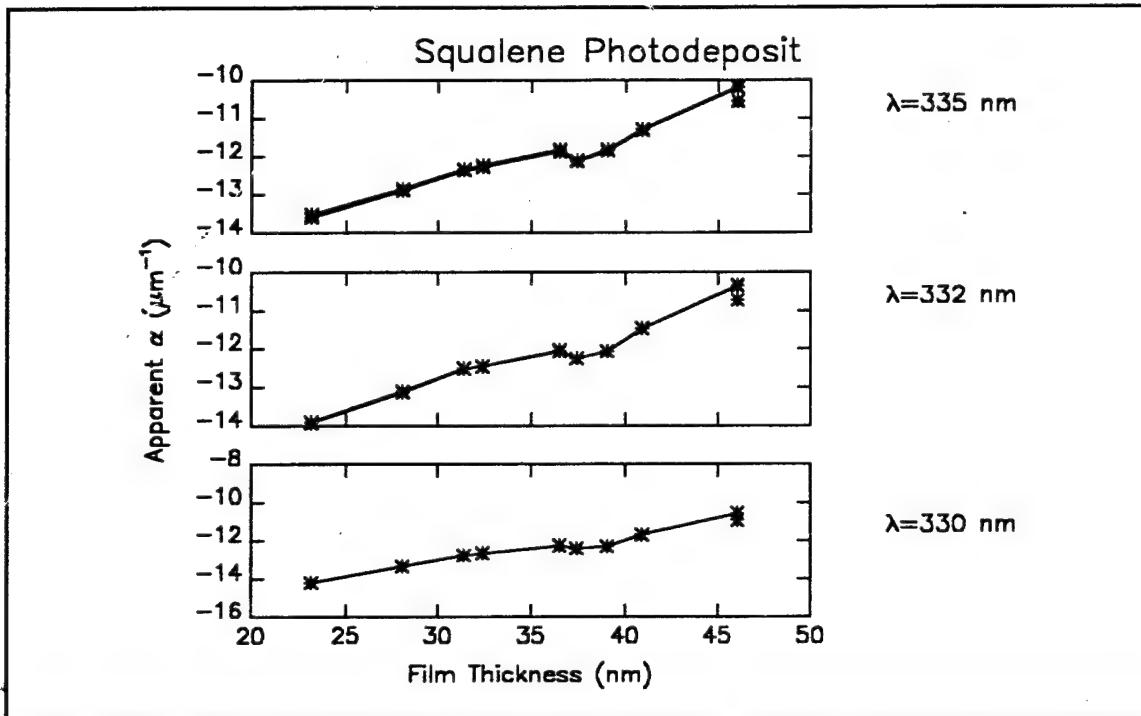


Figure D19i Computed values of α_j for photochemically deposited films of Squalene. (Ultraviolet wavelenght range)

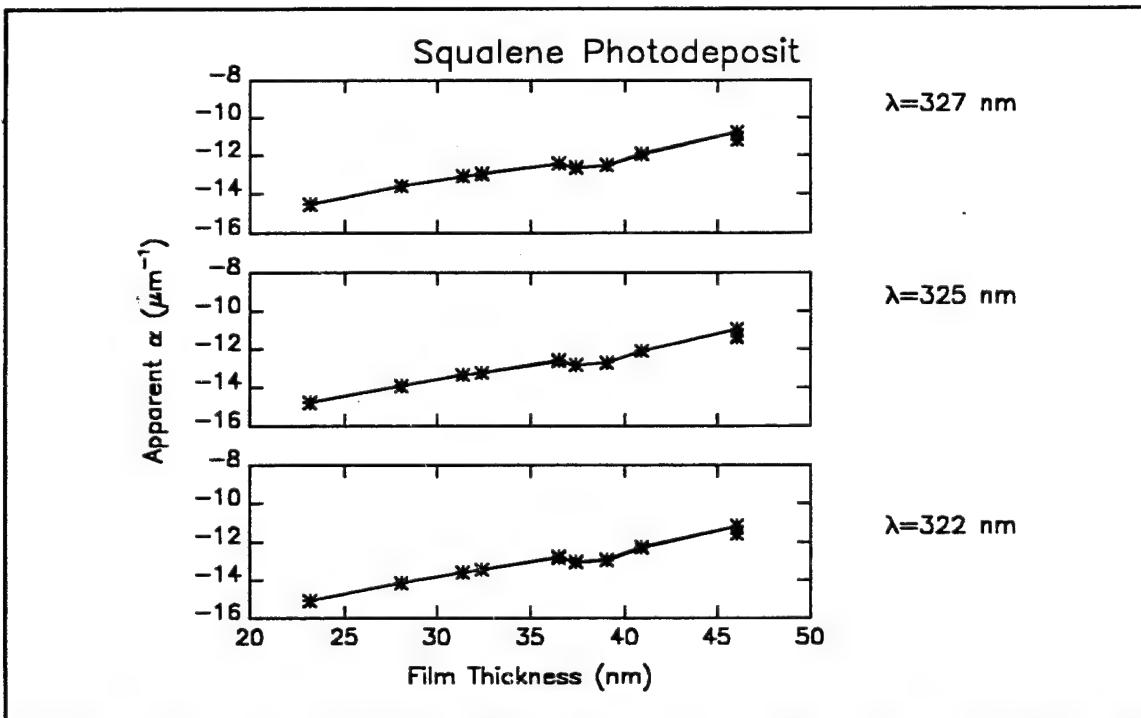


Figure D19j Computed values of α_j for photochemically deposited films of Squalene. (Ultraviolet wavelenght range)

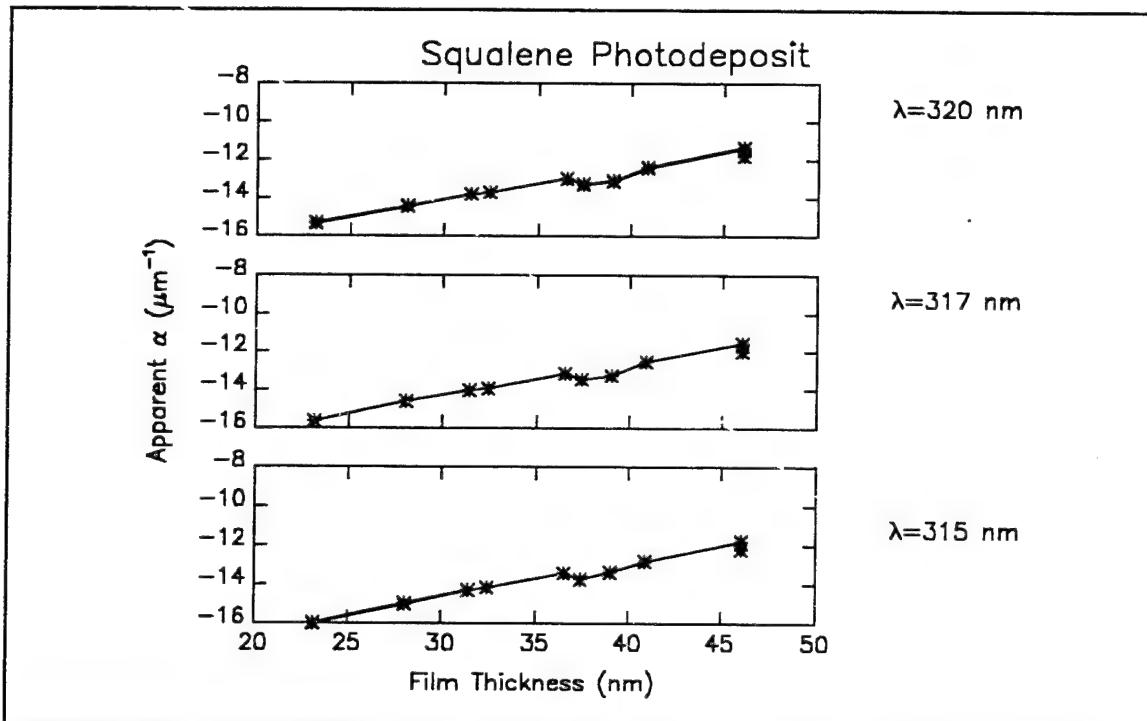


Figure D19k Computed values of α_j for photochemically deposited films of Squalene. (Ultraviolet wavelength range)

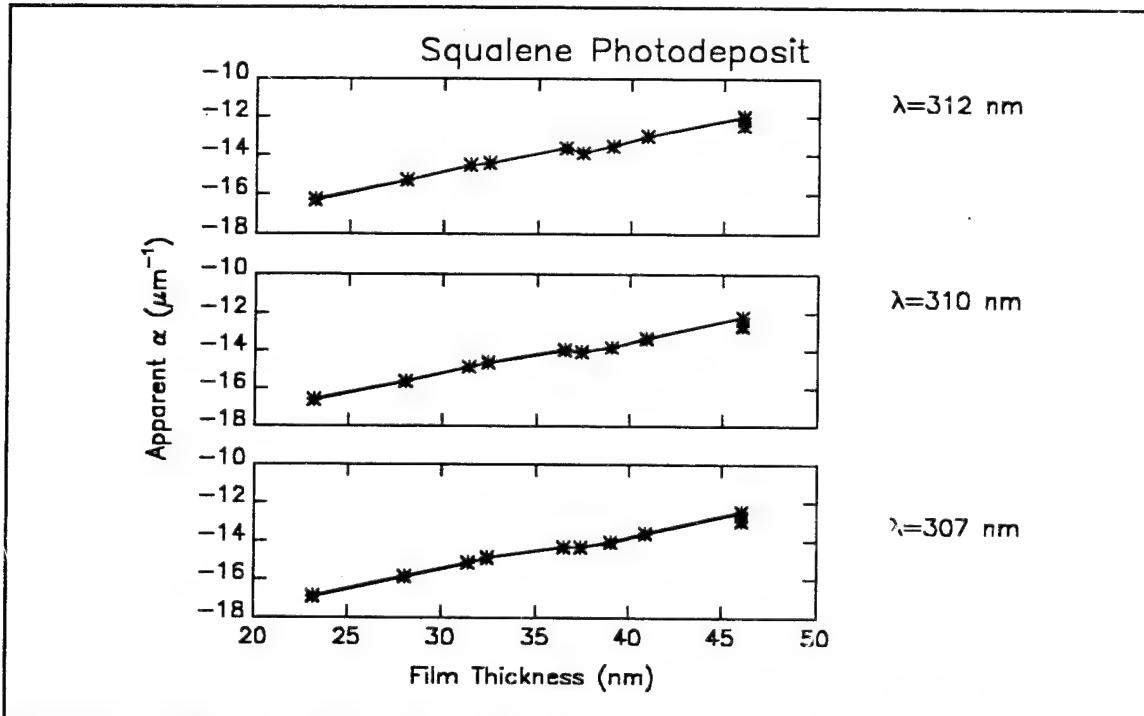


Figure D19l Computed values of α_j for photochemically deposited films of Squalene. (Ultraviolet wavelength range)

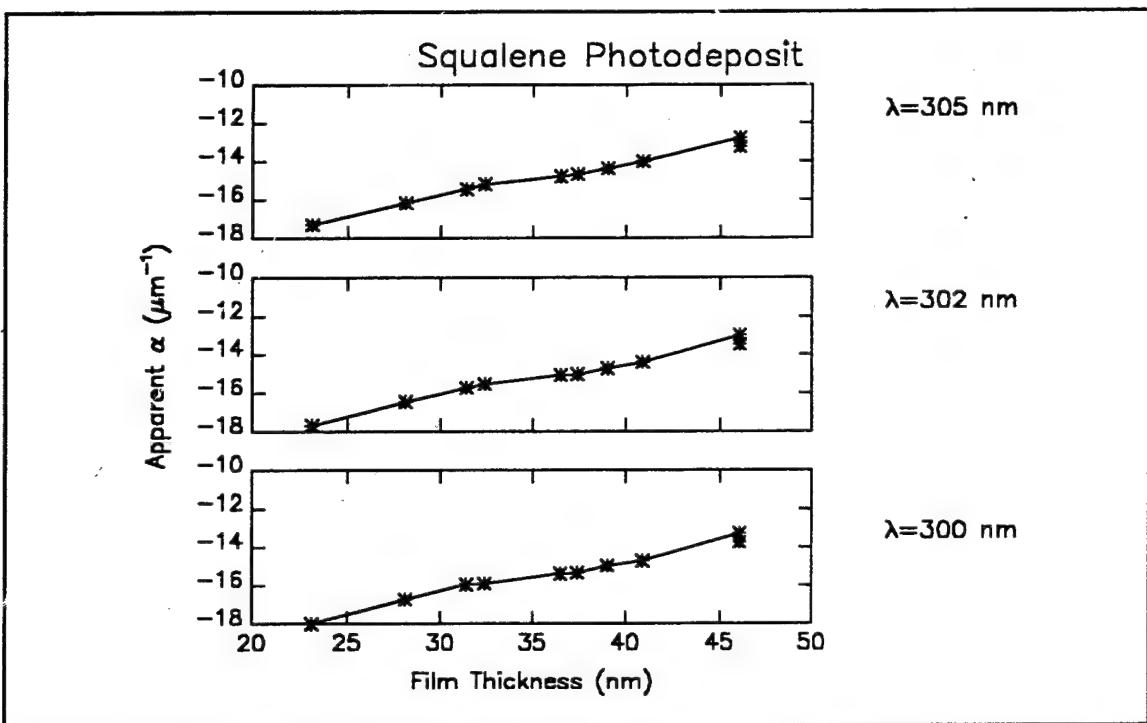


Figure D19m Computed values of α_j for photochemically deposited films of Squalene. (Ultraviolet wavelenght range)

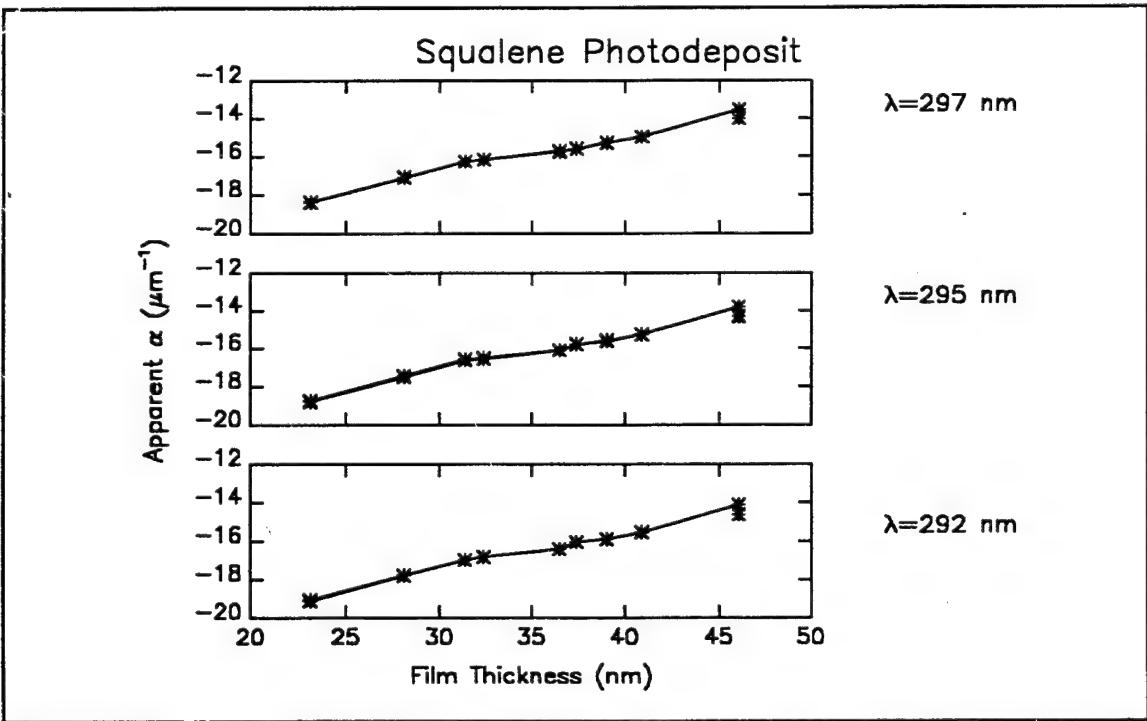


Figure D19r Computed values of α_j for photochemically deposited films of Squalene. (Ultraviolet wavelenght range)

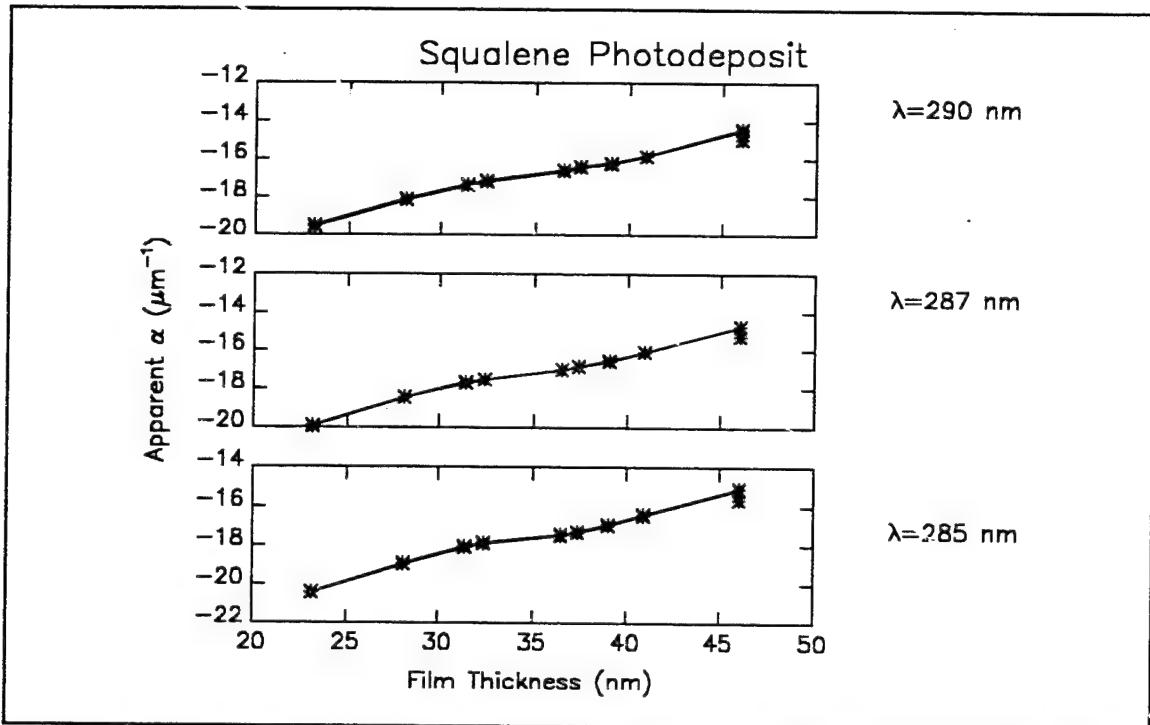


Figure D19o Computed values of α_j for photochemically deposited films of Squalene. (Ultraviolet wavelenght range)

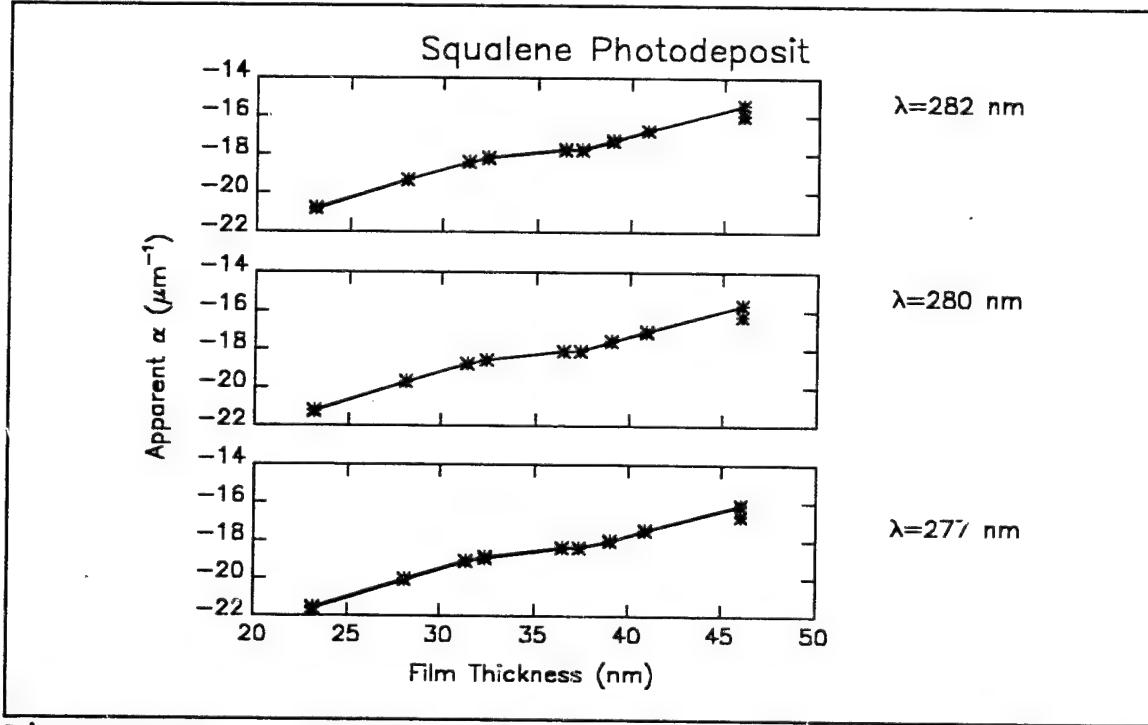


Figure D19p Computed values of α_j for photochemically deposited films of Squalene. (Ultraviolet wavelenght range)

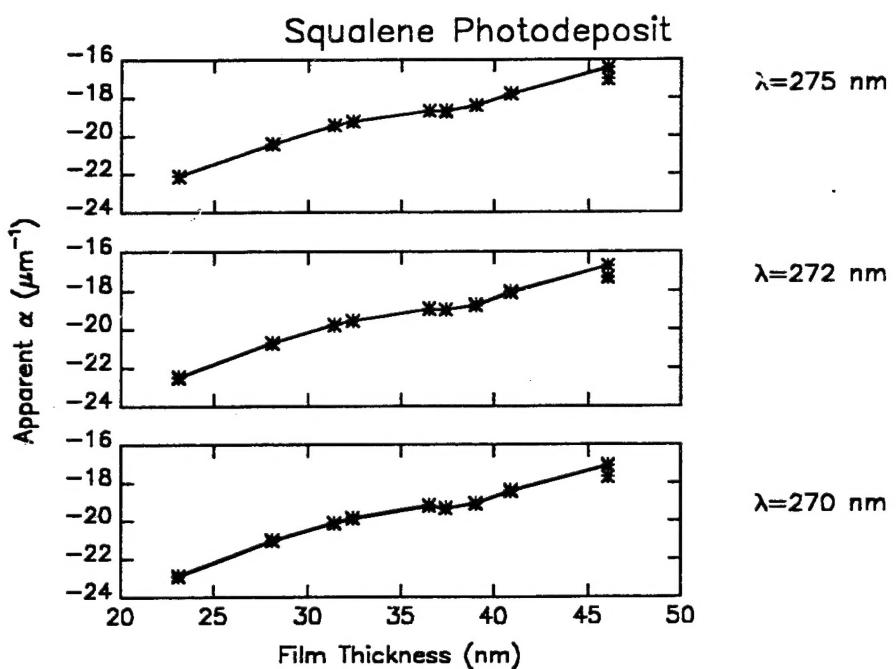


Figure D19q Computed values of α_j for photochemically deposited films of Squalene. (Ultraviolet wavelenght range)

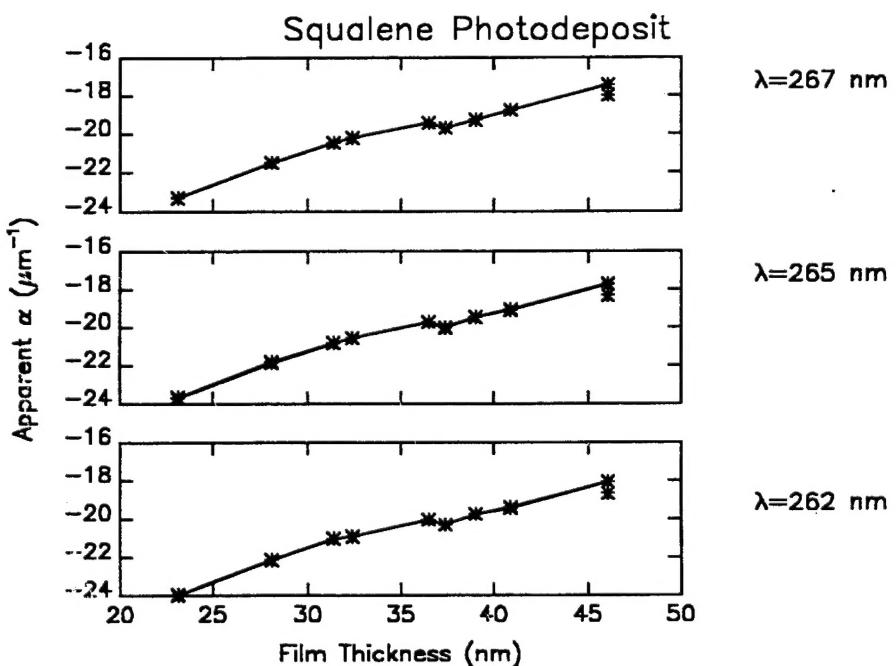


Figure D19r Computed values of α_j for photochemically deposited films of Squalene. (Ultraviolet wavelenght range)

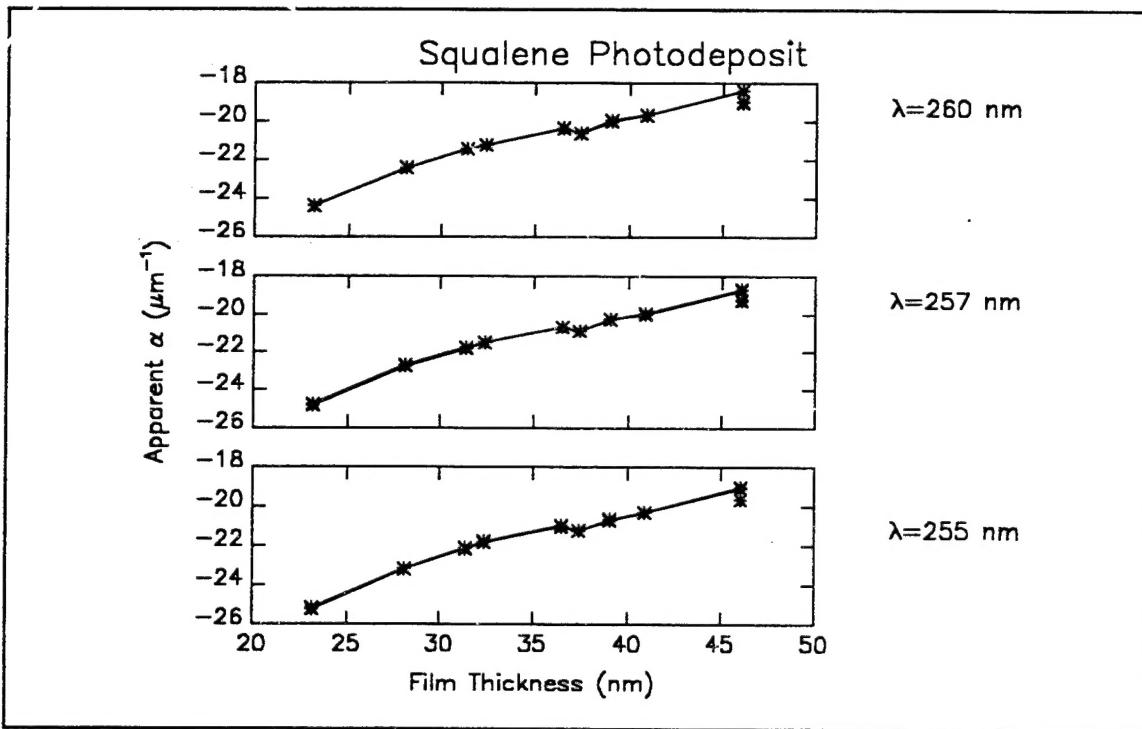


Figure D19s Computed values of α_j for photochemically deposited films of Squalene. (Ultraviolet wavelenght range)

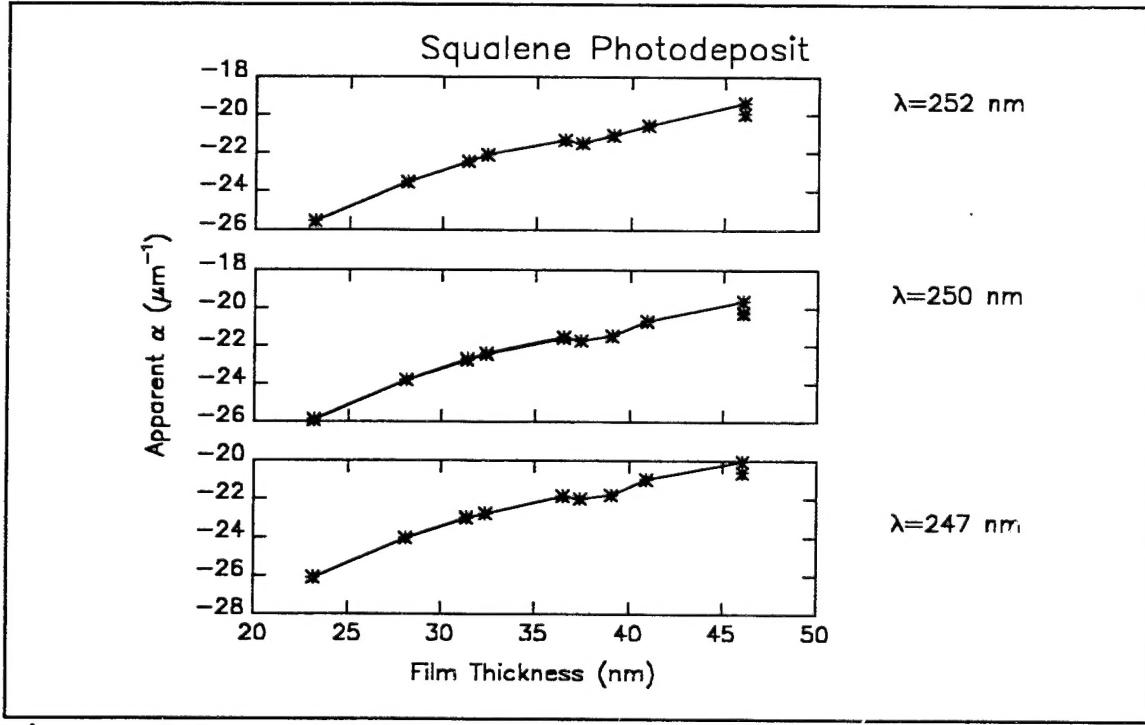


Figure D19t Computed values of α_j for photochemically deposited films of Squalene. (Ultraviolet wavelenght range)

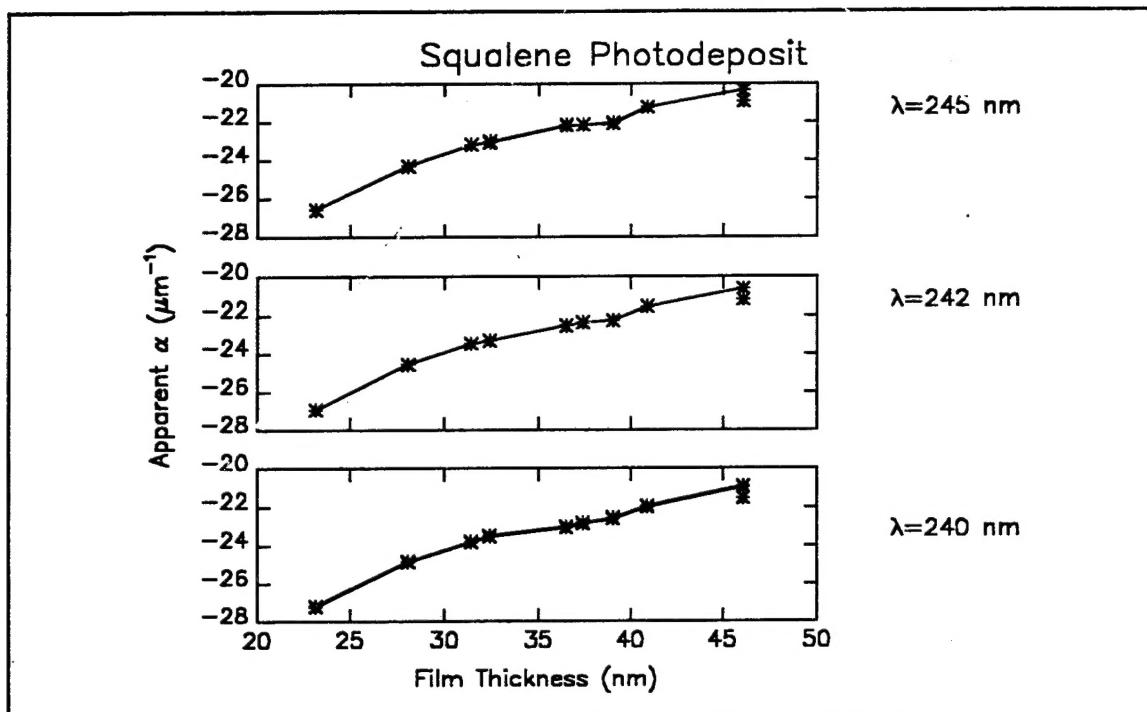


Figure D19u Computed values of α_j for photochemically deposited films of Squalene. (Ultraviolet wavelenght range)

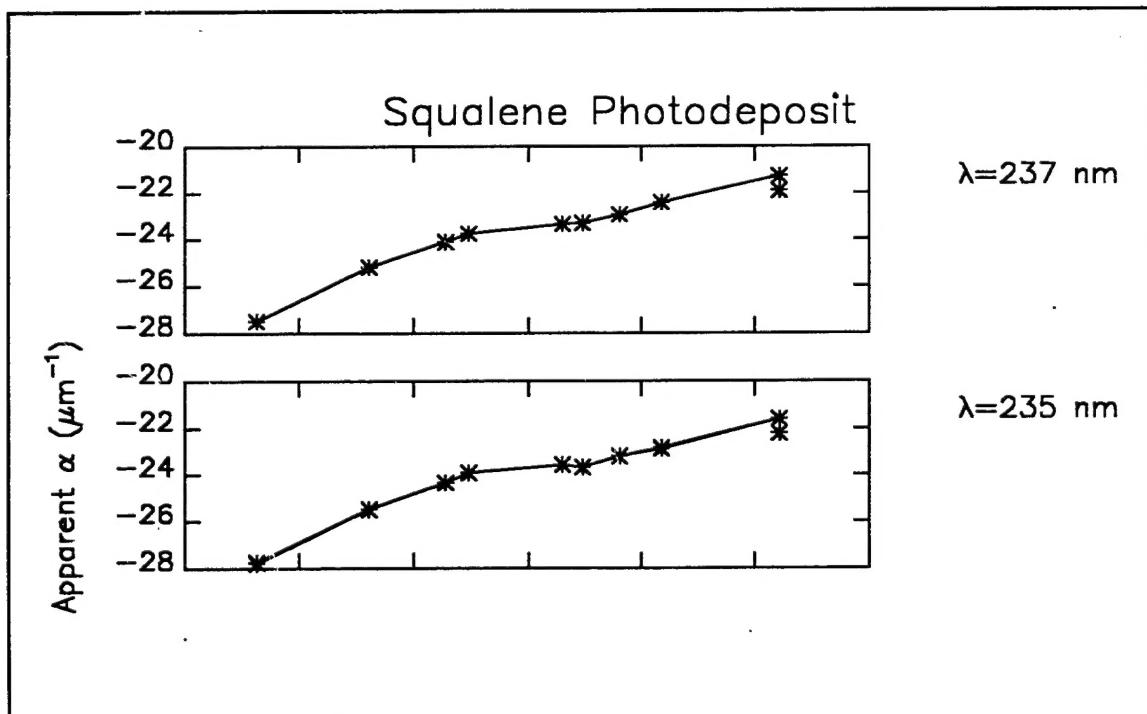


Figure D19v Computed values of α_j for photochemically deposited films of Squalene. (Ultraviolet wavelenght range)

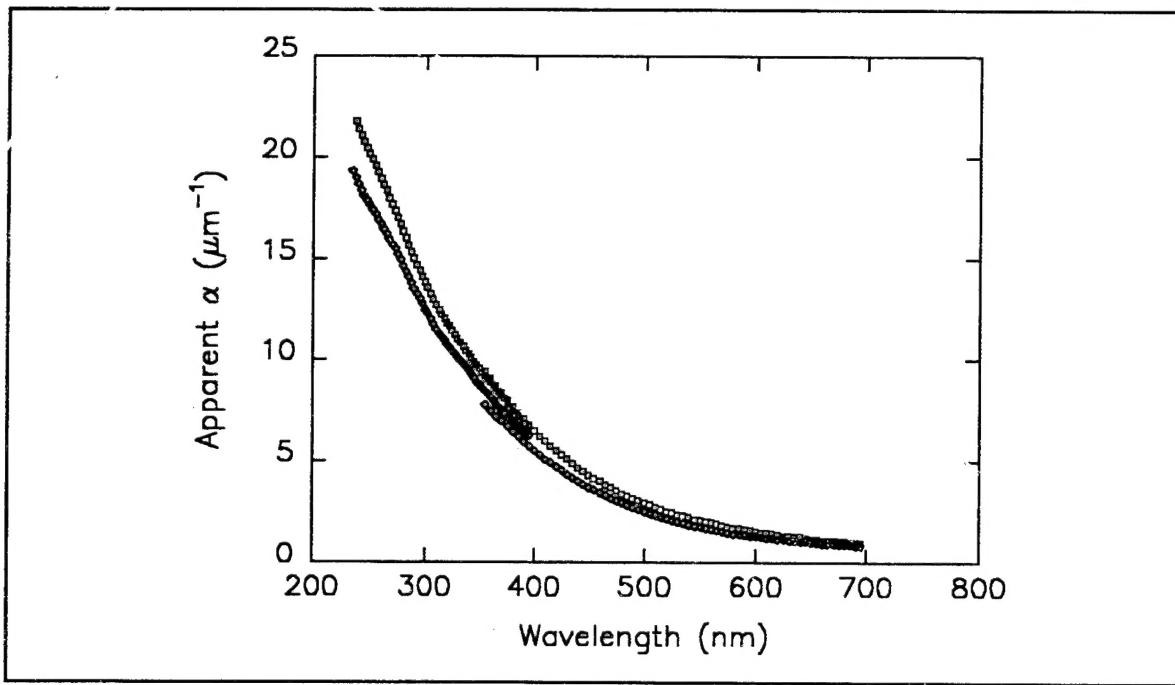


Figure D20. Apparent absorption coefficient (μm^{-1}) of the squalene photodeposited film, linear plot. Squares, averaging for thick films. Diamonds, Beer's law fit of the entire data set.

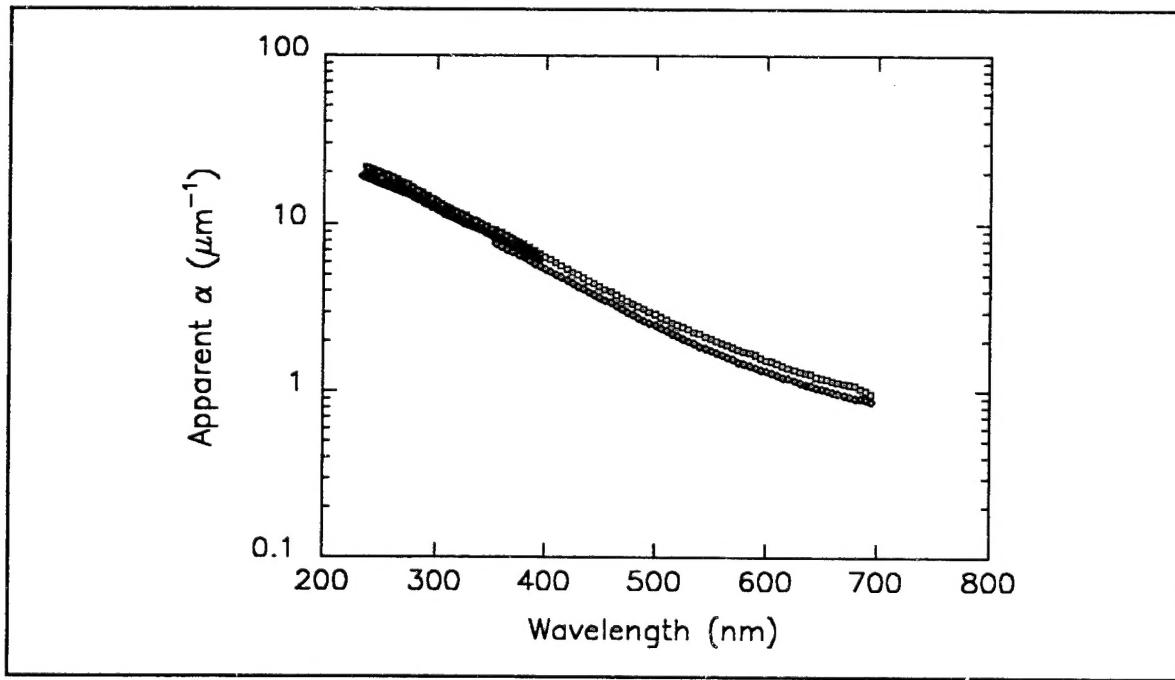


Figure D21. Apparent absorption coefficient (μm^{-1}) of the squalene photodeposited film, log plot. Squares, averaging for thick films. Diamonds, Beer's law fit of the entire data set.